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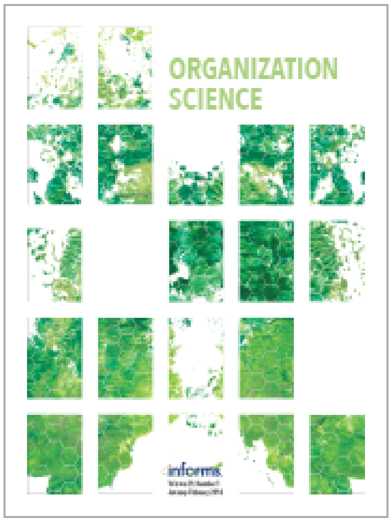

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Data-Induced Rationality and Unitary Spaces in Interfirm Collaboration

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Abstract. The real-time data transfer between collaborating companies allows them to represent and control activities across firm boundaries, providing new ways to organize collaborative efforts. We conducted an inductive multiple case study of five long-term relationships to examine the effects of data-intensive technologies on the organization and management of collaborative relationships in industrial companies. Our analysis shows how the delegation of digital activities into specialized digital units fostered data-driven mindsets and data-driven interactions that jointly formed a holistic data-induced rationality for managing the relationship. Together, the compartmentalization of digital collaboration and the data-induced rationalities turned these units into "unitary spaces," organizational enclosures where structural tensions and competing demands were temporarily suspended to foster single-minded pursuit of collaborative short-term benefits for the partner company.

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Keywords: digital technology • digital transformation • information technology • interorganizational collaboration • structural tensions • supplier-buyer relationships

Introduction

Information technologies have widespread implications for the management of interorganizational collaboration (Boland et al. 2007, Malhotra et al. 2007, Zammuto et al. 2007, Lee and Berente 2012). Digital data allow organizations to establish knowledge-sharing routines for accessing partner capabilities and to create increasingly effective formal governance mechanisms (Hitt 1999, Baker and Hubbard 2004, Malhotra et al. 2007, Im and Rai 2014). More broadly, data-intensive technologies are shaping how organizations evaluate and coordinate activities across boundaries, thus providing companies with new tools for conceiving and resolving problems that arise within partnerships. Although earlier data exchange enabled routine adaptation of transactions, the exchange of rich data, combined with remote control of processes, allows for complex problem solving across organizational boundaries. This suggests that digital technologies may help address diverse issues inherent to interorganizational collaborations, including structural tensions (Das and Teng 2000, de Rond and Bouchikhi 2004, Putnam et al. 2016). Yet, the literature provides little guidance in explaining how data-intensive technologies enable companies to manage the diverse demands of collaboration, such as the clash between collaborative benefits and competitive concerns or divergent short-term and long-term goals (Das and Teng 2000, Pfeffer and Salancik 2003, de Rond and Bouchikhi 2004, Stadtler and Van Wassenhove 2016).

The potential effects of digital data flows on the tensions and contradictions in collaborative relationships have significant theoretical and practical relevance. Digital technologies may shape how actors attend to competing demands (Simsek 2009) as well how they make sense of the paradoxes they encounter (Stadtler and Van Wassenhove 2016). Research has examined how data-intensive technologies create objectified representations of organizational processes and qualities (e.g., Zuboff 1988) and thus, act as "technologies of accounting" (Miller and Power 2013) that make previously concealed characteristics visible and commensurate them into discreet metrics (Espeland and Stevens 2008, Orlikowski and Scott 2014). Digital representation can focus attention and enable both autonomous and collaborative problem solving related to specific problems, which may help partners resolve conflicting demands. Alternatively, they may also accentuate tensions by drawing attention to intractable dilemmas and paradoxes (Das and Teng 2000, de Rond and Bouchikhi 2004, Putnam et al. 2016, Schad et al. 2016). As such, exchange of rich data on business processes can accentuate risks of unintended knowledge spillovers and asymmetric interdependencies. We thus set out to address the following research question. How does the ability of data-intensive technologies to represent and control activities across firm boundaries shape the organization and management of interorganizational collaboration?

We conducted an inductive multiple case study of five interorganizational relationships that employ sensor technology, real-time operational data exchange, and advanced algorithms to facilitate collaboration between suppliers and customers. In each relationship, we collected data primarily from one partner that had invested in data-intensive interorganizational routines: for example, to help reduce equipment downtime and resource use. Although our initial research design sought to compare differences across the five relationships, we found significant commonalities in the tendency of operational employees engaged with data-intensive technologies to locally suspend central structural tensions. Consequently, we refocused our analysis on the prominent dynamics that were evident across all our cases.

Our findings elaborate how organizational compartmentalization of digital units enabled the emergence of *data-induced rationalities*, holistic data-centric conceptions of the world that melded digital data flows, algorithmic processing, and human tasks. These rationalities provided the employees with a coherent set of practices for observing the relationship, formulating issues, reasoning about them, and responding. Data-induced rationalities consist of two mutually reinforcing elements: a data-driven mindset that conceives the collaboration through data, with its purpose as system optimization, and data-driven interactions based on shared understandings derived from data, problem-solving responses triggered by information systems, and frequent low-level interactions. The data-induced rationalities suspended conflicting demands at the interface of collaborating companies by legitimizing and focusing attention on immediate collaborative benefits. Organizational compartmentalization shielded the units from competing demands, whereas data-induced rationality provided a narrow set of legitimate goals. Together, these two conditions fostered "unitary spaces" where structural tensions inherent to the collaboration were suspended and employee attention was focused on cooperative short-term outcomes.

Our discussion section elaborates data-induced rationalities as a broader impact of data-intensive technologies that complements traditional views of technological affordances. We theorize how the seemingly objective and encompassing nature of sensor data can constitute a comprehensive set of affordances to manage relationships that provides humans with a "hyperreal" view of their work context and pushes out the considerations that are not captured by the digital technology. We further discuss the implications of our findings for understanding structural tensions, theorizing how compartmentalized units with coherent data-induced rationalities can form "unitary spaces" that suspend tensions related to collaboration, representing the opposite of "hybrid spaces" (Perkmann et al. 2019). We conclude with a discussion of limitations and future research opportunities.

Digital Technology and Structural Tensions in Interorganizational Collaboration

To investigate the effects of data-intensive technologies on interfirm collaboration, we adopted a structural tensions lens (Das and Teng 2000, de Rond and Bouchikhi 2004, Im and Rai 2008, Stadtler and Van Wassenhove 2016, Aoki and Wilhelm 2017). Interfirm relationships commonly confront managers with conflicting demands that arise from the diverse goals of the interacting organizations, the interdependencies that exist between distinct domains of organizational life, and the practical considerations within the collaborative relationship (Putnam et al. 2016, Schad et al. 2016). Structural tensions relate to the management, organization, and goals of the partnership, and they are thus conceptually distinct from the problems of governance that examine trade-offs and opportunism between the collaborating firms (Uzzi 1997; Baker and Hubbard 2003, 2004; Dekker 2004; Oliveira and Lumineau 2017). We use structural tensions as a lens to examine how the evolving research on the organizational implications of digital data and algorithms informs our understanding of interorganizational collaboration.

Tensions of Interorganizational Collaboration

Interorganizational collaboration is often "paradoxical," requiring organizations to balance "persistent contradictions between interdependent elements" (Schad et al. 2016, p. 10). The pioneering work on interorganizational tensions has drawn attention to several dualisms, such as short versus long termism (Das and Teng 2000), control versus autonomy (de Rond and Bouchikhi 2004, Boudreau 2010), alignment and adaptability (Gibson and Birkinshaw 2004, Raisch et al. 2009), and cooperation versus competition (Das and Teng 2000, de Rond and Bouchikhi 2004, Stadtler and Van Wassenhove 2016, Gnyawali and Ryan Charleton 2018) as well as sharing versus protecting information and knowledge (Henkel 2006, Alexy et al. 2013, Jarvenpaa and Majchrzak 2016). These tensions materialize in situations where individual managers and employees engaged in the collaboration face multiple demands or values that cannot be both satisfied at once (Stadtler and Van Wassenhove 2016). When managers engaged in collaborative relationships feel compelled to attend to and pursue competing needs, they are likely to experience tensions that turn conflicting demands into a paradox or a dilemma (Putnam et al. 2016). Dilemmas and paradoxes represent complex situations that cannot by definition be solved without attending to the competing concerns at once. Although actors may wish to resolve each demand individually, they cannot do so; as Herbert Simon (1962, p. 468) has noted, "in the face of complexity, an in-principle reductionist may be at the same time a pragmatic holist."

Research on structural tensions relates to the broader study of tensions and complexity in organizations, a vibrant and growing domain of research (for reviews, see Putnam et al. 2016, Schad et al. 2016). This literature has examined how organizations manage competing and sometimes seemingly incompatible goals, demands, values, and organizing principles that arise from different organizational units (Lawrence and Lorsch 1967), time horizons (March 1991, Raisch and Birkinshaw 2008), stakeholder groups (Oliver 1990), and value systems (Kraatz and Block 2008, Greenwood et al. 2011, Perkmann et al. 2019). A strand of research has examined tensions across different kinds of interorganizational relationships (e.g., Das and Teng 2000, Im and Rai 2008, Aoki and Wilhelm 2017). Whereas initial studies conceived tensions as detrimental to collaboration and emphasized their destabilizing effects (Das and Teng 2000), more recent literature has emphasized the "generative" aspects of tensions and paradoxes (de Rond and Bouchikhi 2004, Smith and Lewis 2011).

Organizational research suggests four major approaches for addressing competing demands: structural separation, sequencing, integration, and blending. Managers may simply pursue one goal while ignoring or minimizing competing demands or pressures (Oliver 1990), but the risk is chaos, ambivalence, and frustration (Schad et al. 2016). For example, although managers may pursue short-term benefits from an alliance, the choice to ignore long-term considerations can lead to asymmetric dependence on the partner or the failure of the collaborative relationship.

Structural separation addresses competing objectives by assigning responsibilities to separate units (Duncan 1976, Tushman and O'Reilly 1996, Gibson and Birkinshaw 2004). This solution is common in alliances and buyer-supplier relationships where one unit or project pursues explorative goals and another pursues exploitative goals (Brattström and Richtnér 2014, Aoki and Wilhelm 2017). Consequently, different units may develop diverging perceptions of partner trustworthiness and quality because they are not equally exposed to partners' positive and negative collaborative behaviors (Brattström et al. 2019).

Organizations may alternatively engage in sequencing, attending to specific demands each at a time, while bracketing the competing demands temporarily (Gulati and Puranam 2009, Chung and Beamish 2010, Boumgarden et al. 2012, Klarner and Raisch 2013). The sequential attention to demands alleviates tensions, but it may also prevent creative syntheses and lead to suboptimal trade-offs.

The integration of competing demands involves individuals or teams that dynamically juggle competing demands (Andriopoulos and Lewis 2009, Pache and Santos 2012, Zimmermann et al. 2015, Stadtler and Van Wassenhove 2016). Birkinshaw and Gupta (2013) suggest that organizations can seldom avoid an extent of integration, as managers or organizations processes can never fully shield individuals from competing demands.

Finally, the literature has shown that organizations approach competing demands by blending traditional solutions or by inventing new "hybrid" practices or entities that address seemingly conflicting demands at once (Greenwood et al. 2011, Perkmann and Spicer 2014, Perkmann et al. 2019, Smith and Besharov 2019). Akin to integration, the responsibility for handling competing demands is delegated to a unit, but instead of mere situated judgment, the organization develops routines or cognitive frameworks for dealing with them. Blending can involve the development of new structures, shared understandings, and/or organizational culture. In this vein, Smith and Besharov (2019) show how organizations can develop "paradoxical frames" through iterative exploration, governed by a combination of policies, expertise, and stakeholders relationships that they call "guardrails" that maintained continuous attention to these competing concerns. Examining university-company collaboration, Perkmann et al. (2019) illustrate how research universities used structures and practices to create "hybrid spaces" that balance competing demands of academia and industry. The universities accomplished this by selectively reaffirming and loosening specific characteristics of the dominant value system.

This review of the literature draws a complex picture of interfirm collaboration fraught with a plurality of objectives; individuals and organizations often lack the cognitive schema or mental model to evaluate and balance conflicting goals. These interconnected objectives often appear "irrational, inconsistent, and absurd" (Smith and Lewis 2011, p. 387) and need to be managed (Schad et al. 2016). Despite the growing academic interest in tensions, this stream of research has paid surprisingly little attention to the constant proliferation of information systems that capture and mediate potentially conflicting demands. Digital technologies often mediate collaboration processes, shaping knowledge exchange (Malhotra et al. 2007) and forming the basis for coordination (Jonsson et al. 2009, 2018; Im and Rai 2014).

The Effects of Data-Intensive Technologies on Collaborative Relationships

Prior research suggests a range of ways in which information systems can shape organization and management of collaborative activities. A long-standing research stream in operations management has examined how information systems are used to create efficiency and flexibility to support diverse supply chain strategies (e.g., Holland 1995, Reekers and Smithson 1996, Vijayasarathy and Robey 1997, Christiaanse and Venkatraman 2002, Qrunfleh and Tarafdar 2014). Information systems can automate information exchange and coordination to facilitate traditional interorganizational routines, such as ordering, logistics, and interconnected production processes, making them more effective and reliable (Rai et al. 2006, 2012). Digital technologies are commonly applied to facilitate governance, enabling more efficient monitoring (Baker and Hubbard 2003), reducing coordination and transaction costs (Hitt 1999), and facilitating the creation of more complete contracts (Malone et al. 1987, Aral et al. 2018). In addition to such efficiency-focused applications, information systems can also be designed to capture and analyze data more effectively to identify hidden patterns, trends, and opportunities within the broader relationship to facilitate sensemaking and innovation (Im and Rai 2008, 2014).

More recent research from information systems and organization studies suggests that the effects of information systems can go beyond linear improvements. Contemporary data-intensive technologies allow companies to create richer and more timely metrics and evaluations than before (Orlikowski and Scott 2014, Curchod et al. 2020) and to control processes across firm boundaries in new ways, often thereby transforming the content and nature of interfirm relationships (Jonsson et al. 2009, 2018; Lee and Berente 2012; Lyytinen et al. 2016). Taking over crucial aspects of the relationships themselves, these new digital technologies are becoming central determinants of collaboration, shaping rather than merely reflecting interorganizational realities (Baskerville et al. 2020). The "digital first" perspective draws attention to the "ontological reversal" in the relationship of digital and physical worlds, where information systems no longer simply capture and facilitate interactions between firms, but rather, the physical realm increasingly stems from and is enacted as a reflection of digital models (Baskerville et al. 2020). Although the prior data exchanges enabled companies in retail and other industries to effect real-time adaptations to transactions, contemporary technologies facilitate nonroutine problem solving.

Although there has been no explicit attention to the effect these data-intensive technologies may have on how companies experience and manage structural tensions in collaboration, the literature implies two opposite effects. First, technologies may capture previously concealed, compartmentalized, or ignored contradictions and make them more observable and salient. The creation of more comprehensive evaluations within and across organizations (Orlikowski and Scott 2014, Curchod et al. 2020) can elucidate a plurality of valuable objectives, potentially accentuating tensions and paradoxes. Organizations are not monoliths but composed of individuals with their own experiences, interests, and expectations (Lumineau and Oliveira 2018). Thus, interfirm collaboration often unfolds in silos; different intraorganizational coalitions form to adopt distinct partnership logics, and they pursue opposing objectives and have limited insight across coalitions. Where data-intensive technologies create organization-wide understandings, this may highlight competing objectives and accentuate conflict (Brattström and Faems 2019).

Alternatively, digital technologies may substitute existing considerations with new comprehensive objectives that accommodate, balance, or integrate seemingly incompatible concerns, potentially alleviating tensions rather than accentuating them. Information systems that create and analyze digital data flows are effectively "technologies of accounting," which "presuppose and recursively construct" (Miller and Power 2013, p. 561) a certain understanding of the world that "allows the incomparable to be compared" (Miller and Power 2013, p. 562). Research has highlighted how evaluation techniques create commensuration (Espeland and Sauder 2007), "the transformation of qualities into quantities that share a metric" (Espeland and Sauder 2007, p. 16), simplifying and uniting previously complex and disconnected considerations. Digital technologies commensurate diverse observations through "algorithmic evaluations" (Orlikowski and Scott 2014) that draw on large quantitative datasets to relate seemingly incompatible concerns with one another, predict future outcomes, and compress different time spans (MacKenzie and Millo 2003, Faraj et al. 2018). Through predictive and prescriptive learning algorithms that accommodate diverse metrics and prescribe pragmatic solutions (Faraj et al. 2018), organizations may be able to create more encompassing solutions that effectively alleviate or overcome conflicting concerns (Pache and Santos 2012, Perkmann et al. 2019).

Technology may thus resolve seemingly paradoxical situations by turning them into tractable problems by constructing unified "higher-order" rankings or schemes that accommodate seemingly incompatible or incoherent demands under unified metrics and models. Such a process is exemplified by financial derivates, which conflate the variance of value over time and the window of opportunity into a single price (MacKenzie and Millo 2003). Simply by embodying complex reality in metrics, data-intensive technologies can create a seemingly objective view that resolves conflicts, as exemplified by studies of organizational budgets (Mazmanian and Beckman 2018) and materially embedded representations of sustainability in the finance industry (Arjaliès and Bansal 2018).

In sum, data-intensive technologies no longer merely facilitate interorganizational routines but shape how organizations conceive of and address the diverse demands of collaborative relationships. This review suggests that data-intensive technologies may both highlight contradictory collaborative demands and help substitute them with new comprehensive objectives. Despite these theoretical insights on potential dynamics, there remains a paucity of empirical research on how advanced information systems shape how human actors conceive and manage interorganizational collaboration (Boland et al. 2007, Curchod et al. 2020). To investigate these dynamics, we set out to empirically study how real-time digital data flows and related algorithmics shaped internal tensions in five collaborative relationships between suppliers and customers.

Methods and Data

To investigate how digital technologies affect tensions in interorganizational relationships, we adopted an open-ended research design (Eisenhardt 1989, Eisenhardt and Graebner 2007), conducting a multiple case study of five supplier-customer relationships. We sought to identify relevant constructs and their connections embedded in everyday interorganizational practice through rich descriptions and nuanced insights of expert informants (Graebner et al. 2012).

The Empirical Setting

Our study focuses on the transfer and analysis of data in a collaborative relationship between suppliers and customers. The empirical data come from five relationships among industrial companies involving data streams created by physical sensors that measure equipment conditions, functioning, and use. These data-intensive technologies and their use at company interfaces are at the core of the recent developments in manufacturing, commonly called "Industry 4.0" and "Industrial Internet." The adoption of digital technologies allows companies to collect operations-related data from factories and other industrial sites with sensors to optimize existing processes and develop new valuable services. The common purpose of the sensors and data transfer lies in "the technical integration of computer-physical systems into the production and logistics" (Kagermann et al. 2013, p. 18).

Our inductive multiple case study (Yin 2014) design enables us to identify how data flows affect various organizational processes relating to the emergence and management of interorganizational tensions in five long-term customer-supplier relationships. Our five case companies are from the industrial services and equipment sectors in northern Europe. The chosen case relationships are of particular interest because they rely on long-term collaboration that often benefits from cospecialization (Dyer and Singh 1998), and their use of digital technologies is still evolving. Although initial studies of structural tensions examined alliances involving joint development (e.g., de Rond and Bouchikhi 2004), researchers have also documented that these tensions exist in long-term supplier-customer relationships (Im and Rai 2008, Aoki and Wilhelm 2017).

All five relationships we analyzed used data-intensive digital technologies to control, coordinate, and optimize processes related to the domain of collaboration. We include two types of case extensions (Yin 2014) in order to increase variance across cases and get down to the core elements of the mediated collaboration process; first, we include three supplier focal case companies and two customer focal case companies. Second, we include four traditional focal companies adopting the new technology and one "digital native" company. Each focal case company was active in a distinct segment of the industrial manufacturing and service sector. Consequently, our case relationships share a number of characteristics that make them comparable, whereas differences increase the generalizability of our findings. The cases are described in Table 1.

Each of the case relationships had existed for at least eight years when we started data collection. They were all related to industrial production or services in industries such as transport, energy, and manufacturing. The supplier-customer relationships were marked by cospecialization and relationship-specific investments. The companies faced significant price competition, and all of them adopted data-intensive technologies primarily to increase operational efficiency of concrete interorganizational processes, either by raising productivity or by reducing costs. The case relationships can be divided into three categories, involving only data-based services (Epsilon), digitally guided operation of physical equipment (Beta), and a combination of physical equipment sales and data-enabled services (Alpha, Gamma, and Delta). We will next describe these in more detail. All case studies resembled "success cases" by our informants, who considered the relationships to function well and the digital technologies to deliver the intended benefits to a satisfactory degree.

Data-Based Services (Epsilon). The supplier provides a data-based service that helps the customer minimize

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Table 1. Descriptions of Case Relationships and Interorganizational Big Data Technologies

	Alpha (Interviews at customer)	Beta (Interviews at customer)	Gamma (Interviews at supplier)	Delta (Interviews at supplier)	Epsilon (Interviews at supplier)
Relationship description: Investment goods life cycle for all relationships between 10 and 25 years					
Historical relationship	15+ years Equipment and data-enabled services Supplier sold industrial investment goods and associated scheduled maintenance services. Supplier has a separate sales and service unit for irregular customer contact. Supplier's digital services unit is located in an independent organization.	15+ years Operating equipment Concurrent sourcing. Industrial service contracts for the use of large investment equipment (1 month to 12 years)—often mediated by broker. Irregular contact between customer and supplier after the contract is signed. Few years after digital add-on, discontinued the use of brokers.	15+ years Equipment and data-enabled services Supplier sold industrial investment goods and associated scheduled maintenance services. Supplier has a separate sales and service unit for irregular customer contact. Supplier's digital unit is part of the services organization.	15+ years Equipment and data-enabled services Supplier sold industrial investment goods and associated scheduled maintenance services. Supplier has a separate sales and service unit for irregular customer contact. Supplier's digital unit is part of the services organization.	12 years Data-based services From the start, the supplier, a digital services start-up, started selling sensor technology-based consultancy (software as a service) to help the customer optimize their transport operations. Start with just a few installations; now covers the whole fleet.
Impact of data exchange on goal alignment	Data exchange aligns goals High-quality service reduces customer's operational costs. Greater service quality assures future service contract. Digital service sales largely independent from equipment sales—digital services agnostic of equipment manufacturers. Digital services are additional revenue for supplier.	Data exchange aligns goals Customer can monitor and intervene on (previously opaque) supplier's production site to ensure supplier's compliance. Supplier becomes more efficient, making them more attractive to other customers.	Data exchange aligns goals Data exchange allows site-specific demand-based maintenance and operations recommendations, which reduce customer's costs. Supplier provides above-average equipment and service quality, securing future contracts and equipment sales.	Data exchange aligns goals Data exchange allows site-specific demand-based maintenance and operations recommendations, which reduce customer's costs. Supplier provides above-average equipment and service quality, securing future contracts and equipment sales.	Data exchange aligns goals Service quality depends partly on volume and accuracy of data exchange. High-quality service reduces customer's operational costs. Greater service quality assures future service contract.
Technology description					
Digital service purpose and functionality	The supplier originally sold only equipment and maintenance services. Digital services are now offered additionally through the supplier's new, largely independent business unit.	Technology was first developed as internal benchmark to reduce customer's own costs of running their equipment. It was then also implemented on supplier equipment.	The supplier originally sold only equipment and maintenance services. Digital services are a move to continuous service agreements.	The supplier originally sold only equipment and maintenance services. Digital services are a move to continuous service agreements to existing customers and customers operating competing equipment brands.	Relationship is based on this technology. Digital services sold to reduce customer's operational costs.

Table 1. (Continued)

	Alpha (Interviews at customer)	Beta (Interviews at customer)	Gamma (Interviews at supplier)	Delta (Interviews at supplier)	Epsilon (Interviews at supplier)
Technological infrastructure	The supplier taps into their customer's production equipment, draws sensor data to their off-site servers, and analyzes data. Then, the supplier sends visualizations of and recommendations for operations back to customer via a dashboard. Occasional email and phone contact.	The customer obliges their supplier to share operations data via an information system, which draws the data once a day to the customer's server. The customer analyzes the data and sends visualizations and recommendations for operations back to supplier via a dashboard. Occasional email and phone contact.	The supplier taps into the equipment they have sold to their customer at the customer's production site, draws sensor data to off-site servers, and analyzes data. Then, the supplier sends visualizations of and recommendations for operations back to customer via a dashboard. Occasional email and phone contact.	The supplier taps into the equipment they have sold to their customer and other manufacturers' equipment at the customer's production site, draws sensor data to off-site servers, and analyzes data. Then, the supplier sends visualizations of and recommendations for operations back to customer via a dashboard. Occasional email and phone contact.	The supplier connects to the customer's logistics equipment to collect operations data, installs a local server at the site, and sends data to their own servers for analysis. Then, the supplier sends visualizations of and recommendations for operations back to customer via a dashboard. Occasional email and phone contact.
	Both partners have digital services units	Only the customer has a digital services unit	Only the supplier has a digital services unit	Only the supplier has a digital services unit	Both partners have digital services units
Data exchanged	Sensor data on operations (e.g., RPMs, temperatures, pressure, resistance)	Sensor data on operations (e.g., RPMs, temperatures, detailed fuel consumption)	Sensor data on operations (e.g., RPMs, temperatures, pressure, run times)	Sensor data on operations (e.g., RPMs, temperatures, emergency brakes, brake condition)	Sensor data on operations (e.g., RPMs, temperatures, three-dimensional location data)

Note. Bold refers to "case relationship category."

fuel costs through optimized equipment operations. The supplier used the sensor data already created by the customer's equipment and installed a number of additional sensors to collect additional operations data, such as rotations per minute (RPMs), heat, pressure, and its geospatial location. Supplier's software analyzed these data to create and deliver selected metrics, reports, and recommendations back to the customer via digital dashboards. The supplier was a young analytics start-up using a software as a service business model. The customer was one of their first and had influenced the development of the service offering. The customer benefitted from constant reduction of operational costs, whereas the supplier benefitted through a continuous service contract.

The tensions in this relationship derived from mutual dependency and potential lock-in, as the customer held unique market power and prestige, whereas the supplier possessed significant analytics know-how that would have been difficult to replace. The customer was the considerably larger company, one of the market leaders in their industry, with substantive bargaining power. Despite its smaller size, the supplier was among the market leaders in the service area it addressed. Informants noted these concerns of this mutual dependence and lock-in repeatedly in interviews.

Operating Equipment (Beta). The customer developed an in-house digital solution to optimize their internal use of equipment to increase efficiency and equipment longevity. Initially developed in 2010 when the customer asked their own equipment operators to read sensor data once a day and to submit readings to a proprietary information system, this system was later upgraded to feature continuous wireless data transfer. The technology tracked trends in equipment use and created concrete recommendations for equipment operators. The customer engaged in concurrent sourcing (Parmigiani 2007): they complemented their own production assets by additionally contracting their supplier's equipment for periods ranging from 1 month to 10 years. Under this concurrent sourcing agreement, the customer was obliged to pay operation costs for their suppliers' equipment. In consequence, the customer also extended their solution to monitor their suppliers' equipment operation. The customer benefitted from cost savings, whereas the supplier benefitted from increased competitiveness within the industry.

The tensions in this relationship derived from information systems that allowed the supplier to learn how the customer optimized their equipment, risking knowledge leaks to competitors through the supplier. The customer was the larger company, one of the market leaders in their industry, with substantive bargaining power. The supplier was equally a large player in their industry but one with frequent overcapacity. Contracts were conventionally agreed for up to 10 years in order to safeguard the customer's substantial relationship-specific investments.

Equipment Sales and Data-Based Services (Alpha, Delta, and Gamma). Long-standing suppliers of industrial equipment and related maintenance services had all invested in digital solutions to improve the quality and cost of their maintenance services. The suppliers offered a handful of different options, ranging from minimum maintenance to guarantees of uninterrupted uptime and even fuel efficiency. Digital solutions involved real-time transfer of data from the equipment to the supplier's cloud solution, where the data were processed and used to provide dashboard views on its performance and to determine actions to reduce the costs of running their equipment (e.g., unplanned and planned downtime, repairs, spare parts, or fuel consumption). The suppliers in all three relationships represented large firms in manufacturing industries, whereas their customers represented large firms in process industries. The customers periodically bought large industrial equipment with typical life cycles of several decades. A significant part of suppliers' revenue was constituted by maintenance services and spare part sales. Customers benefitted from reduced operational costs, whereas suppliers were able to secure long-term contracts and future sales through the superior attractiveness of their products.

The main tensions in these relationships derived from increasing dependence of customers on the suppliers, creating a tension between short-term collaborative benefits and long-term competitive concerns. All of the three suppliers were market leaders in their industries, whereas customers were either somewhat smaller or of equal size. In adopting the supplier's data-intensive technologies, customer companies made irreversible investments in both capital and development of relationship-specific knowledge. Second, the accumulation of data and customers' lack of expertise risked further vendor lock-in. In principle, vendors had incentives to subtly mitigate the development of analytics competence at customer companies. Our interviews showed that suppliers were well aware of their customers' increasing dependence, whereas customers showed varying levels of concern.

Data

We conducted 55 semistructured interviews in eight companies over three years from 2015 to 2018, as well as three follow-up interviews in 2020 (see Table 2 for details about cases and informants). The interviews lasted between 45 and 90 minutes and were guided by the following main question: "How did digital real-time data transfers affect the relationship?" In our questions, we asked for rich descriptions of the sensor technology itself, rich descriptions of the interactions between the partner organizations before and after its adoption, and the interviewees' perceptions and feelings about the partner organization. In the interviews, we focused on details of concrete interactions between customers and suppliers and the role of the digital real-time data transfers in these interactions. We discussed, among others, people involved, directionality of exchange and reasons for contact, media of communication, frequency of contact, and attitudes toward the partnership. Each interview followed a similar guideline along these points but took shape individually. Early interviews were more open, whereas later interviews concentrated more on clarifications and concrete issues that came up during data analysis.

Our initial entry point to the organizations was middle or top managers in charge of digitalization, who then transferred us to other informants. This snowball sampling (Patton 1990) helped identify the most informed interviewees. We also made sure to cover a wide range of corporate functions and hierarchical levels in order to prevent informant bias in the form of retrospective sensemaking (Eisenhardt and Graebner 2007). Moreover, some of the interviewees we interviewed multiple times (see Table 2). This diversity in sampling provided a multifaceted view of the interorganizational sensor technologies, their interpretations and enactment, and their implications for relationship management.

To triangulate our insights, we interviewed informants of the focal company's partner organization when possible. Unfortunately, some organizations were unwilling to provide us with connections to their customers or suppliers. We further triangulated our findings with data from the organizations' web pages and external communications. Aside from product explanations, investor's communications, and strategic visions for the organizations' future and strategy toward digitalization, these documents also included reports about purchasing practices; articles on the technical development of installations; and videos visualizing the features of sensor technologies, equipment, and services.

Analysis

Our analysis focused on the collaborative processes and practices related to an interorganizational relationship, with specific focus on how sensor data and other digital technologies shape the organization and management of the relationship. We started analyzing data after we had conducted about a quarter of the interviews, enabling us to adjust our interview questions and choice of informants as our understanding of the cases and phenomenon progressed. We began our analysis with open coding of the interview transcripts with the Atlas.ti software. Focusing on diverse

Table 2. Case Companies and Data

	Alpha	Beta	Gamma	Delta	Epsilon
Focal firm	Customer	Customer	Supplier	Supplier	Supplier
Industry	Industrial services	Industrial services	Industrial manufacturing and services	Industrial manufacturing and services	Software as service
Company profile	Traditional	Traditional	Traditional	Traditional	Digital native
Interviewees from focal firm	TM: 0 MM: 4 (3) OM: 3 (3)	TM: 0 MM: 4 (3) OM: 4 (3)	TM: 3 (3) MM: 1 (1) OM: 11 (9)	TM: 1 (1) MM: 4 (4) OM: 9 (5)	TM: 0 MM: 2 (2) OM: 6 (6)
Interviews from counterpart	n/a	MM: 1 (1)	n/a	OM: 2 (1)	OM: 1 (1)
Interviews total	7	7	16	16	9

Notes. *x* indicates the number of interviews. (*x*) indicates the number of interviewees. n/a indicates not applicable.

practices and characteristics of relationships, we created codes such as "incentive alignment," "operational transparency," and "narrower shared goals." Throughout multiple iterations, we identified codes and looked for how different codes were related to one another to make up tentative categories. In a back-and-forth between codes and categories, we renamed some categories, split others, and added new categories. Over time, this process helped us refine tentative categories into stabilized categories (Strauss and Corbin 1990, Grodal et al. 2021).

During the early stages of our analysis, we sought to identify variance across cases (Eisenhardt 1989, Yin 2014, Eisenhardt et al. 2016) and thereby, explain central differences in technology adoption, use, and its outcomes. However, as our analysis progressed, our attention and interest shifted toward commonalities across the cases. All our case companies considered the data-intensive collaboration to be fairly successful, and the technologies appeared to deliver many of the intended benefits. We focused our analysis on explaining how the technologies shaped collaborative practices and processes across our case companies.

The next steps of our analysis were abductive. We observed that all case relationships exhibited what we coded as "incentive alignment" (a code we later discarded). Immersing ourselves deeper into the case (Eisenhardt et al. 2016), we unpacked this code by drawing on the literature of structural tensions. Although within each case relationship, we clearly saw underlying conflicting temporal and collaborative demands, these appeared to be ignored by the frontline employees whose interactions were mediated by the data-intensive technologies. Drawing on the various tensions presented in two seminal articles on interorganizational tensions (Das and Teng 2000, de Rond and Bouchikhi 2004), we identified the collaboration versus competition and long-term versus short-term tensions to be particularly relevant for all of our cases. Yet, the units responsible for collaboration largely ignored these in their everyday work. We coded this as "focus on collaborative benefits" and "focus on short-term outcomes and actions," which we grouped together as "local suspension of structural tensions."

Intrigued by the seemingly frictionless collaboration with data-intensive technologies, we concentrated our analysis on codes that referred to the characteristics and use of the technologies as potential explanation. We sought to identify the attributes and use of real-time interorganizational data flows that might explain the widespread focus on collaborative short-term outcomes. In largely inductive, iterative rounds of coding, we went back and forth between empirically derived codes and empirically grounded tentative categories. We supported these efforts by constantly comparing old coding schemes with new coding schemes and with the data in order to see which codes best describe the cases while at the same time, providing theoretical insights (Grodal et al. 2021). This allowed us to build better constructs and clarify the relationships between them (Eisenhardt et al. 2016). For instance, to explore the notion of "operational transparency," we went through multiple iterations to define what exactly this code denotes. Taking a closer look, we broke it down to "precise metrics" and "visualized operational processes" (we later discarded both these codes again) and found that rather than "operational transparency," the sensor technology provided managers with a "data-based objectified and shared perspective." The second notion of "narrower shared goals" also changed as we engaged deeper with the data. In further analysis, we noticed that the narrower shared goals are the outcome of what we coded "collaborative routines conceived through data," making the latter the more insightful and theoretically relevant code to describe our data. In this process, we formed the categories "data-driven mindset" and "data-driven interactions." Taken together, we noticed that these two categories seemed strongly related and mutually reinforcing. The "data-driven mindset" provided organizations with an understanding of reality, whereas "data-driven interactions" provided a frame for action. We thus related these two categories to bring about a new category that we named "data-induced rationality."

To explain how exactly the use of interorganizational big data technologies facilitates this local suspension of tensions, our analysis became again more abductive. Revisiting the literature on interorganizational tensions and specifically, the various structural and organizational design approaches to manage them discussed in the literature review (e.g., Gibson and Birkinshaw 2004, Stadtler and Van Wassenhove 2016, Aoki and Wilhelm 2017, Smith and Besharov 2019), we focused our analysis on the organization of the units in charge of developing and delivering digital services. We noticed that these units showed strong "unit autonomy" and a "mandate for partner utility," which we captured with the category "organizational compartmentalization," resembling structural separation.

In the final stage of our analysis, we formed a theoretical model (Figure 1) that elaborates the relationships among our categories. Identifying the "local suspension of structural tensions" as the outcome of introducing data-intensive technologies, we interrogated our data to see how exactly "organizational compartmentalization" and "data-induced rationality" brought this about. We could see clearly that "data-induced rationality" provided the motivation to only attend to immediate operational goals that were represented in the technology. After some consideration, we then observed that "organizational compartmentalization" was instrumental in bringing about "data-induced rationality" in the first place and that it also maintained the "local suspension of structural tensions" by limiting the demands faced by the digital services units.

Findings

Our analysis revealed an almost complete absence of overt tensions when informants described the practices and activities in the collaborative relationships. The units responsible for managing the relationship were almost exclusively focused on cooperation to achieve the promised operational efficiency goals and worked toward short-term objectives. Through our interviews, we found that although competitive and long-term concerns resurfaced periodically when the relationship was up for renegotiation, they were effectively suspended in the collaborative interactions.

This section proceeds as follows. In the first subsection, we describe the digital services units and how their compartmentalization shielded them from diverse demands from the broader organization. The next subsection details how data-intensive technologies and compartmentalization gave rise to a coherent data-induced rationality in these units, consisting of a data-driven mindset and data-driven interactions. The third and final subsection elaborates how organizational compartmentalization and data-induced rationalities locally suspend the structural tensions inherent to the relationships, forming what we call unitary spaces.

Organizational Compartmentalization

All of our case companies organized their digital technologies in separate units with strong autonomy to develop and apply digital technologies to facilitate interactions with the partner. The units had a strong mandate to pursue benefits for the partner that further shielded them from demands within the broader organization (see Table 3).

Unit Autonomy. The organizations had "compartmentalized" digital services into specific units, with responsibilities for both developing and managing the digital services. Apart from the case Epsilon, all our focus organizations were historically industrial manufacturing or services companies with core expertise in mechanical engineering and operations. The core business of these companies involved the development of investment goods with long product life cycles and/or

Figure 1. Data-Intensive Technologies Locally Suspend Structural Tensions

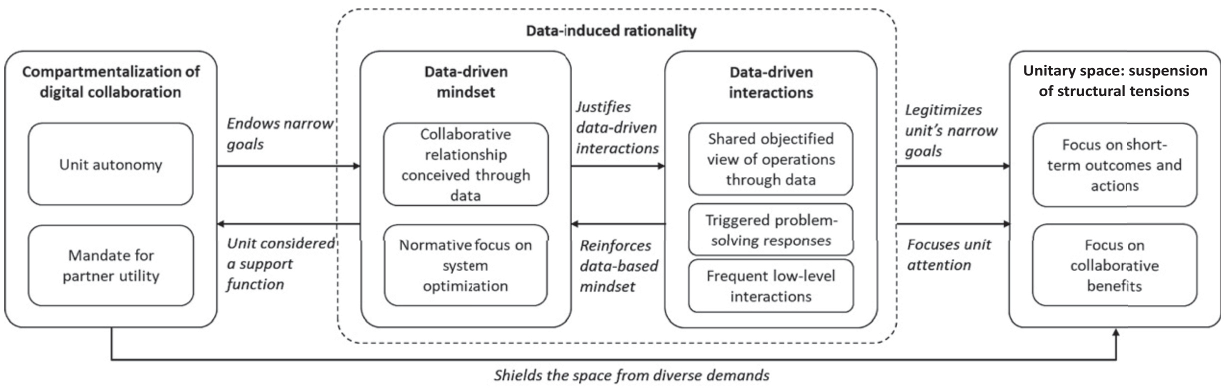

Table 3. Organizational Compartmentalization

Organizational compartmentalization	Alpha	Beta	Gamma	Delta	Epsilon
Unit autonomy	"It's in the software those notifications are created and there would be email content, but there would also be a weekly meeting. So you would deal with those notifications also on request. You would phone these guys and discuss the subject" (OM, Alpha, customer)	"So that means our performance manager, on a monthly basis has a cell phone meeting with the performance managers of other companies and tell them that how we see performance emerging in their scorecards." (OM, Beta, customer)	"[N]ow we have really taken a big leap toward customer-driven development and also innovation from our side. So, we are of course listening to our customers and, trying to get feedback from them. But also trying to be innovative and trying to think about solutions which the customer don't even know they need" (OM, Gamma, supplier)	"[W]e collect each call, each email, etc. Each separate case we can track down later on and we can decide do we need some training on this issue or do we need some more information, is our documentation good enough for reality, there is like a lot of perspectives, how to use the data" (OM, Delta, supplier)	"[Within an established project], certain kinds of configurations can be done by an analyst, it is not a huge development project, but it is still a bit of work." (MM, Epsilon, supplier)
Mandate for partner utility	"[Our supplier made some initial data point selection] we provided feedback, and then we added some of the KPIs we want to see and the sensors we needed for that. And then we build the dashboard the way that the [site] wanted to be read" (OM, Alpha, customer)	"For us, [our own and partner installations] are same because we are responsible for the fuel bill of the company, and we are supplying fuel equally to [our own and partner installations]." (OM, Beta, customer)	"It [the focus] depends on a segment. For condition monitoring you need to have high risk of failure. It should be associated with a big cost. […] For some areas it is important to optimize fuel consumption. If you come there with condition-based monitoring, there is no use, they don't have such a criticality of operations." (OM, Gamma, supplier)	"[I]f you think about your home laptop, somebody from somewhere can help you. You can allow them to take an online remote connection to your laptop and assist you, how to fix it or how to find something from laptop, so we can do the same thing, actually. So it's not directly giving nothing new, but we have the knowledge what to find and where." (OM, Delta, supplier)	"[W]e have everything delivered … we are always developing it further, we are always developing the next level of service. It is always the interactions, it always goes around improvement" (MM, Epsilon, supplier)

related industrial services. The digital services units represented distinctive expertise, employing experts with different skill sets, educational backgrounds, and professional history than their colleagues in the core business. In contrast, the supplier in case Epsilon represented a newly founded technology-intensive firm. All of the units were granted significant autonomy to rapidly develop and improve the digital solutions, with strong support from their organizations' top managers.

Case relationship Beta illustrates the freedom that digital units enjoyed. The customer in case relationship Beta had developed their own internal scorecard initiative to improve fuel efficiency of their operations. They had established a small digital services unit responsible for creating a set of digital capabilities initially for internal use, and subsequently, they extended it to selected partner organizations. The team identified relevant sensor data points; developed algorithms; and built the software to gather data, analyze them, and report the findings. The customer organization had pooled domain experts from their core business and paired these with a selection of data scientists to work independently to develop this digital service. The manager in charge of this process described the powerful role of the unit in designing the system.

> The data structure where the raw data is gathered needs to be centrally governed [by the digital service unit]. Before [each department] all run around buying and building our own solutions. So with the new system [the digital service unit] are building, we are basically [giving] the business the criteria [for data inputs]. This is where we want [internal departments or suppliers] to dump their data. Before [internal departments and suppliers] move anything off to reporting and analysis, [the digital services unit] need to set criteria and algorithms for how to deal with the data. —MM (Beta, customer; edited for clarity)

The autonomy extended to handling external relationships. After the digital service was operational, the team was tasked with rolling it out to select groups of key suppliers: "[We start with the suppliers with] the biggest [installations], the longest contract, the most consumption, our important pool of suppliers" (OM, Beta, customer). The digital unit asked the partnering supplier companies to share a specified range of equipment data on regular daily intervals for analysis and sent them back a curated dashboard. The digital service unit was responsible for directly addressing any questions from suppliers and assisting them via phone, email, and occasional site visits: "[The supplier] basically calls and picks up the phone if there's an issue, and says, okay, I need something on this. And [we] say, okay, you need to talk to that guy. So, it brings us closer and faster in the handling of other matters as well."

In case relationship Gamma, the supplier organization had developed a new service range to optimize the operation and maintenance of equipment they had sold at the customer site. This service collects equipment data from the customer's production site, sends it to the supplier's servers for analysis, and then, pushes dashboards back to customers. The digital services team had developed the service and was fully in charge of its daily management and further development. One of the managers involved in the development elaborated on this.

> It was to some extent manual, we had to do that ourselves, to look at the spectra to analyze data … but before we went to the market we built an automated system for analyzing the spectra and other data that we could get from [equipment]. Then there was a first version that performed quite well. To develop that we had to get quite competent people with university education in mechanical engineering and electrical engineering. We recruited external partners for software development [to create] that data acquisition system and central automated data analysis. And then after the first version was launched to market, we have improved automated analytics so that we could make our projects more efficient and also more effective. —OM (Gamma, supplier)

To facilitate rapid development of the service, the unit interacted directly with the customer and had freedom to decide the functionality to develop. The engineers in the digital services unit often sought feedback from their customers about specific equipment performance issues and digital services. An interviewee explained: "When we have a new service in mind we will make a mock-up or a demo version. Then we will take a customer and show them this mock-up and let them interact with it, see how it works, ask for their suggestions and then see how we can improve the concept" (OM, Gamma, supplier). Because the involved competencies and solutions differed from the traditional business areas, the innovation process took place almost exclusively within the digital services unit, with little intervention or oversight from other units or higher-level management.

Mandate for Partner Utility. Operating largely autonomously from broader organizational and interorganizational demands, these digital services units had one main goal—to optimize practices and processes at the interface of collaborating companies. The digital services units we studied had all a clear mandate to improve interorganizational outcomes and faced no direct accountability for financial goals. The employees in digital services units sought to develop new services that would identify and analyze sources of improvement for the performance of practices and processes carried out by the partner company, providing clear and unambiguous goals for their work. One manager in case relationship Delta summarized his mandate this way:

"I will try to think everything, I try to think myself in this technician's shoes and try to see what they are seeing" (OM, Delta, supplier).

The focal company Delta developed a data-enabled service to help partners operate machinery made by it or its competitors. The digital services unit had developed solutions to gather and transmit data from their customers' production site; analyze them; and create customer-specific dashboards and recommendations for better handling, operating, and maintaining the equipment. This new range of data-enabled services showed a rapid development and success, justifying the continued autonomy and partner-focused mandate of the unit. A manager in the digital services unit described how the development was driven by partner preferences.

> [T]he most typical way is that the customer is asking for some features, e.g., we would like to see this and that on the screen, of course we can't develop our services according to each feedback, because there would hundreds of different features. But if we get several demands from customers about the same type of features they would like to see, then we are taking this into the development pipeline. —OM (Delta, supplier).

Because the unit had no profitability targets, it could focus the development and operation on the demands of its partners: "[W]hen I visit the customers, when I see that they are describing their problem which is costing money or downtime, it shows immediately the payback for this problem. Then you don't need many of this kind of feedbacks. Because with this type of customer, they might all have this problem, but they haven't all figured out this issue yet" (OM, Delta, supplier).

In case relationships Alpha and Epsilon, both the customer and supplier organization had highly compartmentalized digital services units. This facilitated a strong mutual focus on operational optimization. For instance, in case relationship Alpha, the customer organization started building their own internal digital services unit to support their operations. The customer wanted to learn more about their equipment performance in order to optimization equipment operations and maintenance but lacked the required data science know-how to do it alone. The units shared their knowledge openly, and the supplier interacted frequently with the customer's employees to improve its services ability of optimizing the customer's internal operations. A manager from the customer explained that

> we are giving [our supplier] access to our scheduled maintenance events on this piece of equipment [and] all the sensor data from that equipment. [We are asking them to] recommend to us, which one of these planned events we can defer or cancel. So, what they are delivering to us is recommendations for how to adjust our maintenance schedule. —MM (Alpha, customer)

The partner-centric mandate of digital services was explained in part by the distinct economic logic in the companies. Nearly all other units in our case organizations, apart from the supplier in case Epsilon, were financially responsible for growing their revenues and maintaining profit margins. Unlike the traditional industrial services units, the digital services units we studied followed the logic of a support function; they had large fixed costs, and their partner-specific costs were not scrutinized. The digital services units we studied were seen as necessary and beneficial investments for the future. They were seen as crucial for increasing overall sales or helping the companies maintain the competitiveness of products and services, but they did not have their own sales force, revenue numbers, or profit margins. To illustrate, one manager in case relationship Gamma highlighted the importance of digital services for the continuous development of physical products and services that become increasingly augmented by digital components: "[W]e really tried to go with the digitalization to this outside in thinking and looking from the values of the customer like this [data-augmented services]. Predictive, that what are their needs, if the sky is the limit" (OM, Gamma, supplier). Additionally, a manager in case relationship Delta highlighted benefits for relationship management.

> But, now it's more or less like this whole idea of [our portal] is to bring it all together, like all the relevant information for the customers. And, build a good customer experience so to say, so that we don't have this like scattered around systems where customers tend to get lost, but we have only one place where you log in, you get all the relevant info from there and there you go, basically" —OM (Delta, supplier)

The supplier in case Epsilon represented an important exception because the company as a whole focused on selling digital services. Upon signing their contract, the supplier installs a range of sensors to their customer's production site, also tapping into equipment provided by other physical equipment suppliers. The supplier then transmits data to their servers (in some cases every couple of minutes), analyzes the data, and makes dashboards and reports available to the customer. The customer in relationship Epsilon leveraged these insights to increase the efficiency of their operations and maintenance. Yet, even in this case, the logic of partner-centric goals prevailed; the activities with the large pilot customer we studied were shielded from immediate financial considerations. The digital unit responsible for serving the partner approached its interactions as a means to develop a better, more differentiated service offering: "[W]e have the commitment from the customer that they are interested and that they codevelop the product with us" (MM, Epsilon, supplier).

Data-Induced Rationality

Our analysis revealed that all digital service units were driven by strong *data-induced rationality*, a shared normative understanding of what information ought to be attended to, how it should be processed, and how the conclusion should be enacted. The ability to capture the relationship through data engendered a data-driven mindset and data-driven interactions that together aligned customers and suppliers around shared short-term collaborative targets. Our informants described virtually all of the interactions among the companies as aimed to optimize concrete outcomes and pursued optimization through an objectified view of key processes, captured in metrics, graphs, and figures derived from interorganizational flows of data (see Table 4).

Data-Driven Mindset. The units responsible for managing the data-augmented relationships we studied demonstrated a strong data-driven mindset. This involved a shared perception of the collaboration through data, with its purpose as system optimization. Digital services units perceived the reality of the relationships through automatically generated flows of digital data and conceived their tasks in terms of optimization of specific outcomes. Their claims about the goals of the relationship were formulated in terms of quantitative indicators, and virtually nobody mentioned more qualitative goals or outcomes without being prompted for them. Informants were often unwilling to even discuss issues that could not be measured, such as increased dependency. Remarkably, none of our informants appeared to consider the labor costs inside the unit; in cases where service work involved costs (Gamma and Delta), these were calculated as part of the optimization problem. Not only did the employees have a strong normative focus on system optimization, but the system also consisted exclusively of elements they had data on.

The case relationship Beta exemplifies the widespread belief that the relevant aspects of the partnership could be gained from analyses of sensor data. The customer had obliged the supplier to install sensors that they used to create an efficiency scorecard. This objectified view of the interorganizational relationship provided quantified metrics of the suppliers' activities as a set of metrics including fuel consumption and deviations in equipment that increased operational costs. The dashboards were also used outside the digital services unit, providing a data-based assessment of the collaboration.

> [W]e [the digital services unit] give them [internal colleagues from other units] our feedback about how the performance has been and the cooperation level and the competence and the commitment and the engagement parts. —OM (Beta, customer)

Similarly, in case relationship Gamma, the unit responsible for maintaining and servicing the customer's equipment conceived their work through the analytics created and transmitted by the equipment they had sold. The equipment functioning could be conceived in terms of various quantified sensor-based measurements of equipment condition, fuel consumption, and power output. Employees from both organizations commonly conceived the collaborative efforts in terms of these metrics. One manager noted, "from our IT system, we can show to the customer the health of the equipment, how it is working, how much fuel it consumes and its efficiency" (MM, Gamma, supplier).

Large volumes of interconnected digital data were central in allowing digital services units to conceive their partner company's activities as a system to be optimized rather than as a set of disconnected optimization problems. As an interviewee from the supplier in case relationship Epsilon explained, "if you want to really bring advantages to a specific customer, you should understand what makes that customer's process more efficient, add value there. For example, how can they shorten [their production cycle]" (MM, Epsilon, supplier). Such comprehensive considerations linked data, analytics, and various optimization problems under an overarching goal of improving customer operations.

A key exception to the widespread efforts to optimize customer efficiency was relationships with performance agreements that guaranteed the customer certain fixed efficiency and uptime, which motivated the suppliers to minimize their own costs rather than their customers' costs. No such relationship was included in our sample, but suppliers in relationships Gamma and Delta discussed them. Yet, even in these cases, employees conceived the relationships and activities through digital metrics and perceived their job as system-level optimization.

Data-Driven Interactions. Data-induced rationality extended beyond the data-driven mindset to concrete practices that enacted the inferences derived from digital data and algorithms. We used the term "data-driven interactions" to capture how the shared view of operations derived from data analytics triggered concrete problem-solving responses through frequent low-level interactions. Because the data-driven mindset made organizations conceive relationships as a series of optimization problems that the companies could jointly address, political conflicts seemed almost absent, and interactions seemed to involve minimal judgment. Data-intensive technologies triggered automated alarms generated by algorithms, effectively framing the issues around digital representations and problems of optimization. Consequently, most interactions were triggered and guided by the information

Table 4. Data-Induced Rationality

	Alpha	Beta	Gamma	Delta	Epsilon
Data-driven mindset					
Collaborative relationship conceived through data	"Having the availability of the data will probably make you more keen to get more insight into the technical and the engineering aspect of things and will develop more conversation about why is it doing this, and how can this fix it, and how does this really work in practice et cetera. So I think it will also change the, the nature of the conversation" (OM, Alpha, customer)	"We send the score cards to all the [supplier] so they can see it, yes. With names on. I: How did they react? R: We had a lot of communication. We had some that were very angry, but we also had some that were very, very competitive and wanted to be number one and invested in being number one." (OM, Beta, customer)	"So we've been developing different kind of sensors, that you can put into the [equipment], see how the [different parts are] doing and what's the ambient condition and all kind of things" (OM, Gamma, supplier)	"Also at the same time this information on how the [equipment] itself is being used and how it wears out, provides us then an additional edge in, situations when the customers need an upgrade or when they need a new investment. So you could even argue that we know better than our customer what sort of [equipment] do they actually use, or do they need in their environment" (TM, Delta, supplier)	"And we try to enable, we intend to enable them to first of all compare the assets, so that they know the technical performance. Within a class of [equipment] they are quite well comparable." (MM, Epsilon, supplier)
Normative focus on system optimization	"[The performance improvements we delivered to our customers] of course have changed the way the customers, our customers see us. I'm not saying it's because of this exclusively, but our customer satisfaction survey scores have increased dramatically over the last four to five years." (MM, Alpha, customer)	"We work very much with KPIs in house, so we've had a lot of KPIs for own [machinery] for telling them they were not efficient or were efficient. So basically we extended it to the [contracted part of our operations] and made benchmarks, saying, okay, based on the normal levels of [an internal machinery] group A, B, or C […], how are they doing?" (MM, Beta, customer)	"In the agreements depends on what are we actually monitoring, what are we looking at, why is it important for the customer, what are the drivers for the customer, so is it about availabilities, about performance and what should be [goal]." (MM, Gamma, supplier)	"The entire idea of equipping the [equipment] with sensoring capabilities with sufficient amount of intelligence so that it can, really sense its own status. And also its environment. And modify its operation based on the information that is receives and is able to communicate this status and these findings, to remotely back to us. And also locally to the other equipment or the users. That only has multiple benefits both in the use of equipment and the maintenance itself and so forth." (TM, Delta, supplier)	"Usually we comment something that 'have you noticed that this and this has happened?' Some of these reports require some interactions, we need some input from them. If we calculate some savings on the basis of the data we may need e.g., current fuel prices or some additional info from the customer" (OM, Epsilon, supplier)

Table 4. (Continued)

	Alpha	Beta	Gamma	Delta	Epsilon
Data-driven interactions					
Frequent low-level interactions	"The supplier will contact you for minor things that you have never seen before. So it definitely changes the frequency of the contact" (OM, Alpha, customer)	"Now they basically call and pick up the phone if there's an issue, and say, okay, I need something on this. And say, okay, you need to talk to that guy. So it brings it closer and faster in the handling of other matters as well" (OM, Beta, customer)	"We have all these indication and warnings if something goes wrong, we can come to the customer, can call up the customer and say that, your [equipment piece] three, the [part A] needs to be adjusted according to this and this." (TM, Gamma, supplier)	"No it's a real-time, online type of algorithm. It has to be that because, if it is for example, detecting some critical failures, so it has to be reported right away, to real users or to our, technical support (…), only then we can guarantee the real-time performance of those algorithms" (MM, Delta, supplier)	"So everything that the [customer] sees is automated. We are collecting information, doing the models, and then giving modified information back to the [customer] and giving them these recommendations how to [operate]." (OM, Epsilon, supplier)
Triggered problem-solving responses	"Then if you get more and more integrated, you, they can have a remote access to the system directly, so instead of waiting for them to send you the data or having to go [off-site], there can be, maybe they are able to log on to the systems remotely from their offices and make some kind of real-time troubleshooting." (OM, Alpha, customer)	"So there are recommendations along with that. We have the team in […] that they are open for calls or mails, so whenever they have questions, they can reach out and say, okay, why is it bad?" (OM, Beta, customer)	"Because already today we are able to do some adjustments remotely. So, if a customer has a challenge with a [equipment type A] for example—you need to be very precise how they are adjusted. To feed the exact [regulation] (…) But, today with this connectivity, we can do it so that we don't need to send anybody [on site]" (OM, Gamma, supplier)	"This [smart equipment features] was picking up in the market and we also noticed ourselves at the time that, the information we got back to us from the [equipment] how they were functioning how they were being used, was something that we could then use and utilize to a larger, and to better extent. In supporting our customers also then developing our own service operations." (TM, Delta, supplier)	"If you have this screen [on site] that tells you the [operations specifications] at each point in time, and advises you to adjust the [operations accordingly], that helps them [the customer' operators] maintain the optimal [position]. And this could help you save a couple of percent, or even a couple of millions." (MM, Epsilon, supplier)
Data-based objectified view of joint operations	"And then for each single data sensor we will look at the results and make sure that the result that is provided is in accordance to what is expected. And if not, then we have time to calibrate the sensors." (OM, Alpha, customer)	"We decide, I don't know, the twenty data points that are relevant for performance optimization and we pull them home at the intervals that make sense." (OM, Beta, customer)	"What are the concrete measurable fuel savings, I think that's number one. And then secondly it's about this availability, reliability type of things that, calculating, what's the true availability" (OM, Gamma, supplier)	"Giving simplified presentation that what's happening within the whole engines. Is it good or bad and what is this outcome, if this (X shows)" (OM, Delta, supplier)	"So [the screens] are showing how well are [the installations operating]. If they are not at the optimum they are consuming more energy." (OM, Epsilon, supplier)

system, and they were done between technical employees, ranging from technicians to chief engineers, with minimal oversight from higher hierarchical levels. The same data in the shared objectified view of operations then closed the loop, tracking immediately and automatically the success or failure of real-time problem-solving interventions.

The data-based shared objectified view of operations created by the technology is illustrated well by case relationship Delta. The supplier collected data from equipment at the customer's production site to construct dashboards with key operational metrics, such as running time and brake condition, as well as safety alerts. The shared dashboard highlighted deviations in performance using color codes and provided recommendations on addressing these inefficiencies: "[D]evices are connected to our remote service so they can see summaries of the remote data, e.g., basic condition […] what should be done" (OM, Delta, supplier). These dashboards were often accompanied by concrete recommendations, and they triggered concrete data-driven problem-solving responses. Recommendations included services provided by the supplier, such as needs-based maintenance or safety training. One manager explains it like this: "[T]he [equipment] should tell us, or somebody, I need something. I think that's nowadays trend. People want that. They want these things say that what they want. I need to be charged. I need something. People are coming a little bit more like, they are expecting so much from devices, is it the phone or laptop or whatever in your home" (OM, Delta, supplier).

The contacts in all relationships were predominantly triggered by algorithms, and their goal was to address acute issues, such as suboptimal use of equipment that suggested potential for increasing efficiency. The focus on narrowly defined problems stood in contrast to predigital relationships that involved broad periodic interactions to maintain and improve the relationship. In relationship Gamma, the supplier's digital services unit continuously analyzed the data to identify potential problems using a combination of automatic algorithms and human data science. One informant explained that, "in the era of cost savings we are in, it boils down to optimizing everything you're doing. It's optimizing the [equipment operations], so you have the best fuel consumption, that you are [meeting the schedules] exactly" (TM, Gamma, supplier). The employees and managers in the customer and supplier organization treated these issues as acute; deviance from the perceived "perfect world" was no longer seen as inevitable but rather, as a time-critical problem that needed to be responded to.

Data-intensive technologies had greatly increased the frequency of low-level interactions between companies, whereas prior to digitalization, contacts had been less frequent and often instigated by business managers. These changes are illustrated by case relationship Gamma. Using the sensor data collected from equipment, the supplier's algorithms continuously assessed maintenance needs and operations efficiency. Data were analyzed by engineers trained in data science, who initiated direct contact with engineers at the customer organization to address deviations from the calculated ideal. One employee explained that "we have the possibility to connect with the customer's installation, monitoring their parameters in real time, and then [for example] extending the intervals of their maintenance or suggesting new things" (TM, Gamma, supplier).

These frequent low-level interactions with technical focus were also evident at Epsilon, where one manager described the relationship practices as follows:

> When we start to prepare for installation of our system, we have an engineer going [on-site] installing our system, we integrate to the different systems [and equipment on-site], we start to collect data, which takes [some] months, then we are able to do the models for our solutions, and that is where the activation happens. [After that], the customer can begin to collect the savings, because we are giving recommendations on how should they operate the [equipment]. Then reporting becomes crucial, we evaluate how [the equipment] performs against the expectations [derived from] our recommendations. —MM (Epsilon, supplier)

The dynamic was slightly different in case relationship Beta, where the data were analyzed by the customer rather than the supplier. As discussed, Beta's interactions were based on a shared objectified view constructed by the dashboards. Somewhat different from the other cases, interactions were periodic rather than triggered by algorithms. The nature of the logistics operations in this case relationship made it practical to provide daily overviews and instructions. One manager at the customer organization in case relationship Beta described interactions to be strongly linked to and triggered by performance reports.

> [O]n a daily basis, [operating sites] are reporting in our performance management tool, and this tool is basically a data collection tool. So, all the data regarding the consumptions, the speed, the load [etc.], everything is entered by the [installation] on a daily basis and comes into a big database, and then we have [software that] generates different kinds of reports in order for us to, to evaluate and check if the [installations] are within our tolerance levels. —OM (Beta, customer)

Just like in the other case relationships, the digital technologies had greatly increased the frequency of interactions. Collaboration also became considerably closer with the introduction of the technology, even cutting out the middleman: "[N]ormally all dialogue was going through a broker, basically. We closed that and had the dialogue directly with the supplier" (MM, Beta, customer). The increased the frequency of interaction was connected with a shift in interactions from business managers to engineers.

Unitary Spaces: Local Suspension of Structural Tensions

Our analysis showed that organizational compartmentalization of digital services units and new data-induced rationalities aligned the interests of collaborating companies in what we term "unitary spaces"—organizational enclosures where structural tensions and competing demands are temporarily suspended to foster a single-minded pursuit of aligned goals. In our cases, these goals represented collaborative short-term benefits related to interorganizational collaboration. These digital services units did not resolve underlying inherent structural tensions but effectively ignored them in their everyday interactions (see Table 5). In this section, we describe this focus on collaborative benefits and short-term outcomes that arose from the compartmentalization and data-induced rationality in digital service units.

Focus on Short-Term Outcomes and Actions. The digital services units in all five case relationships prioritized immediate short-term outcomes, with very little concern for long-term outcomes for the relationship or the participating organizations. The focus on short-term performance was most prominent in cases that prioritized fuel consumption and other immediate operational costs (Beta and Epsilon). For example, in case relationship Beta, the companies focused on the reduction of immediate operational costs associated with services contracting: "[W]e're not here to argue or blame, we're here to fix. So rather than going into a two-year court case on proving you spend […] too much, we'd rather fix it and make sure you're not spending […] too much from now on" (MM, Beta, customer). This momentary and situated disregard of longer-term implications strengthened in-depth conversations about how to further drive operational cost reductions.

The suppliers' digital units that we studied acknowledged longer-term considerations privately and during contract negotiations. For instance, in case relationship Gamma, in developing their data-enabled services, the supplier considered the costs and profits of a number of interrelated service elements from original equipment sales to maintenance services and spare parts sales. One informant described the process the following way.

> And then again, [forming] the agreement depends on what are we actually monitoring, what are we looking at, why is it important for the customer, what are the drivers for the customer, so is it about availabilities, about performance? […] we combine the field service, and combine the spare part deliveries. —MM (Gamma, supplier)

Yet, after the contracts had been agreed upon, the focus within the unitary space was on short-term choices, such as real-time adjustments to equipment operation or identification of acute training needs. The focus of activities was broadly on the outcomes that benefited the customer: "If in our opinion this engine is going to break down in two months, [we ask ourselves] how can we make sure that doesn't happen and it gets sorted out before that" (MM, Gamma, supplier).

Our case companies varied in the orientations they had prior to the introduction of data-intensive technologies, but in all cases, the collaboration had become more intense. Case relationships Alpha, Gamma, and Delta, all of which preceded the introduction of the data-intensive technologies, were relatively arm's length and exhibited temporal tensions mainly between short-term revenues from equipment sales and the long-term revenues from service sales. Yet, these structural tensions had been largely dormant because the business units responsible for equipment and service sales remained largely separated.

It is important to note that all case relationships faced demands that competed for attention; the pursuit of short-term benefits was imperfectly aligned with securing the long-term survival of the relationship and company-specific competitiveness. To illustrate, in case relationship Beta, the customer had interest in immediate increases in operational efficiency to reduce operational costs (i.e., fuel costs). For the supplier, maintaining the relationship in the short term meant in large parts to simply keep their customers happy. The customer was concerned that in the long run, however, the supplier organization would absorb its proprietary know-how to create lasting improvements in their capabilities, thus eroding the customer's cost competitiveness in relationship to its competitors who use the same suppliers. At Beta, one manager described the temporary advantage they were able to enjoy.

> [Hype around big data] has created to some extent an awareness that there's a lot more to be done with data and to be derived from data. Truth be told, although we pioneer and are, I think, well ahead of competition when it comes to doing stuff with fuel efficiency data, I think the industry at large is still pretty much lagging behind other industries. —MM (Beta, customer)

Some suppliers were enquiring whether they could buy the digital service for use across all their customers: "[W]e also had a few of them [our suppliers] asking, can we buy your system? We have never seen such a good system" (OM, Beta, customer). They also

Table 5. Local Suspension of Structural Tensions

	Alpha	Beta	Gamma	Delta	Epsilon
Underlying conflicting demands	The supplier has strong incentives to keep the data and analytics proprietary; customers are increasingly dependent on the supplier if the analytics methods are not shared and the organization is unable to develop analytics capabilities.	Improvements to suppliers' performance can be enjoyed by competition. Short-term costs to suppliers that only lead to benefits in the long term.	Supplier is unable to capture the additional value it creates for customers. Improved service quality decreases lucrative spare part and maintenance sales. Customers risk becoming increasingly dependent on the supplier.	Improvements in service quality decrease the revenues for the supplier in spare part sales and maintenance.	Customer can assimilate suppliers' skills and techniques, making it redundant. Supplier's openness reduces the added value it can create to customer, eroding its bargaining power.
Local suspension of structural tension					
Focus on collaboration	Supplier's digital unit focused on maximizing equipment efficiency and reducing the downtime and faults in customer equipment.	Customer's digital unit focused solely on improving the supplier's service performance.	Supplier's digital unit focused on maximizing equipment efficiency and reducing the downtime and faults in customer equipment while attending to service costs.	Supplier's digital unit focused on improving the efficiency of equipment and addressing on-going concerns, such as safety risks at the customer site.	Supplier's engineers focused solely on helping the pilot customer understand and improve its processes.
Focus on the short term	Supplier recommends interventions that increase equipment efficiency and reduce planned and unplanned downtime.	Mutual attention to fuel consumption and risks that can be immediately addressed.	Mutual attention to operational metrics, such as efficiency and downtime, informing immediate actions. Choices take into account life cycle servicing costs.	Supplier recommends interventions that reduce planned and unplanned downtime and address equipment misuse and risks.	Mutual attention to recommendations that can be immediately implemented.
Illustrative quote of collaborative short-term focus	"They [our supplier] said: 'well, we are interested in developing some software for this [predictive maintenance] that we'll want to sell to the industry. And if you want to work with us in this phase, then you'll have a head start ... ' [...] So we said okay" (OM, Alpha, customer)	"I think most of them have been very interested and open, and I think the starting point has been that it's a learning process. We want to share. You share. And hopefully we can all improve, right. So it has never led to any claims on that side. But it's more to bring some facts into the discussions." (OM, Beta, customer)	"I think that it's a common journey to discover how with digitalization we could improve the life of our customers." (OM, Gamma, supplier)	"You can see how [component A] is doing and what's the ambient condition and all kind of things (...) Then you need to understand that if that sensor tells you that thing, in that particular user, in that way the customer uses it, it's likely that that particular product would fail in let's say two month, so you can act proactively and connect the service to that. That requires that you have enough understanding of that kind of processes that the customer is running" (MM, Delta, supplier)	"We go to the customer and have analytics workshops, highlighting what we are seeing from the data and trying in that way to convey the message what the reports are telling and get in fruitful discussions" (MM, Epsilon, supplier)

explicitly recognized that some suppliers were learning from them and copying the solutions: "[M]any [suppliers] are investing in systems [to provide similar benefits to] their other customers" (OM, Beta, customer). Although the digital technologies had resolved previous tensions that arose from suppliers' opportunism in implementing short-term cost savings that were against customers' long-term interests, a new trade-off between short-term increases in efficiency and the long-term erosion of competitive advantage emerged.

Focus on Collaborative Benefits. In unitary spaces, the employees and managers tended to recognize conflicting interests of customers and suppliers, but then, they largely ignored them. There was a systematic lack of attention to the competitive concerns that might conflict with the cooperative demands, such as appropriation of value or asymmetric interdependence. In case relationships Gamma and Delta, the supplier and customer had conflicting interests in the use of replacement parts and maintenance services. The customer wanted to minimize these costs while keeping the equipment operational. Because these additional purchases represented a significant share of suppliers' revenue, it was in the suppliers' interest to convince customers to make more purchases. Yet, our informants noted that the units responsible for data-intensive services could freely ignore or even undermine the sales targets of business units. This is illustrated by the digital unit in Gamma that was solely focused on "thinking about the best of the customer, to give the best advice" (MM, Gamma, supplier). Likewise, in relationship Delta, the unit responsible for managing the relationship was solely focused on meeting the service quality that had been agreed on with the customer. One manager explained the following.

> [S]ome customers, they use the [equipment] every now and then. If it doesn't work, they have some other solution to do the thing, for example, they have [an alternative equipment-type]. It's not that critical. But, there can be some other values for those customers. They want to, for example, take care of the safety of the operator. So, then we need to offer something that, serves them in order to keep the workplace safe. —MM (Delta, supplier)

The sole focus of collaboration was associated with a strong belief that the pursuit of mutual goals would pay off to the extent that attention to more competitive concerns could be ignored. In case relationship Beta, the supplier went beyond its contractual obligations in seeking to create collaborative benefits. One informant explained: "[W]e gave them our own performance system and reporting system, and that was actually way beyond what they are contractually obliged to report" (MM, Beta, customer). The supplier's fuel efficiency did improve, which reduced the bill for operating costs the customer had to pay as per the contractual agreement. The supplier soon recognized the benefits of sharing operations data and following their customer's recommendations.

Because digital units were compartmentalized and perceived as a quasisupport function by the top management, they were not evaluated by their ability to create profits. This provided a degree of protection from competitive demands. As long as the digital services continued to provide value in terms of stronger customer relationships for suppliers and higher-value operational processes for customers, managers were reluctant to impose competing demands on the digital services units. Asked about the priorities of a digital unit, one manager reflected the following.

> We are completely transparent with our efforts, we want to always provide the best performance for the customer, that's the goal. If they [the digital unit] give the best advice, the equipment works better and that is good for our company reputation and our customer's operations. —MM (Gamma, supplier)

The focus on collaborative benefits was confined to the unitary space. All case organizations were aware of the potential erosion of competitive position and profits because of overt focus on collaboration. Concerns about competition arose frequently in relationship renegotiation or customers' internal evaluation processes. To illustrate, in case relationship Beta, despite the resulting focus on the benefits of cooperation, the relationship remained strongly shaped by the high cost focus and competitive spirit. This became most visible in hard renegotiations that used digital data from their collaborative relationship in driving a hard bargain: "[W]e had a very constructive dialogue with their management. It's one of our biggest suppliers. We basically told them, you know, this is nonnegotiable. If you are not stepping up to this, then we will not take the [service] with you anymore" (MM, Beta, customer). The digital services unit was often contacted by other departments that were interested in concrete metrics that prove the supplier's dedication to continuous improvement: "So yes, we [the digital services unit] give [reports based on metrics and supplier's attention to optimization] to our own organization. They play a very important role during their negotiations [with the supplier]" (OM, Beta, customer).

Customers we interviewed expressed concerns about the long-term erosion of skills and bargaining power or the risk of becoming dependent on their suppliers. Yet, as shown, these considerations were disregarded in the unitary spaces by both suppliers and customers as the attention focused on system optimization at the interface of the collaborating firms. One manager noted: "I think maybe the biggest challenge today is to figure out the business model how to be paid for what we are doing […] it's a little bit of a free service, but in the end, you have to get paid for it" (TM, Gamma, supplier). Similarly, in case relationship Alpha, both the customer and the supplier recognized the need for and benefit of collaboration while remaining aware of the difficulty of appropriating a "fair" amount of the created value in the long term: "There needs to be a level of trust. If you then optimize processes, how can we find a balance on sharing the gain?" (MM, Alpha, customer).

Discussion

In this section, we build on our inductive study to develop a theoretical model, explaining how organizational compartmentalization and data-induced rationality can give rise to "unitary spaces," and then, we discuss the model's two central implications. As the first implication, we theorize how digitalized processes and comprehensive data can create data-induced rationalities. As the second implication, we elaborate unitary spaces as a form of organizing premised on compartmentalization and a strong data-induced rationality that leads to the suppression of structural tensions. We conclude by discussing the limitations of our study and the opportunities for future research that arise from them.

Theoretical Model: Compartmentalization, Data-Induced Rationality, and Unitary Spaces

Our theoretical model consists of three elements: the compartmentalization of digital services units, data-induced rationality, and unitary spaces that locally suspend structural tensions. We first elaborate on how organizational compartmentalization of digital collaborative efforts facilitates the development of data-induced rationalities in self-contained units and then, elaborate on how these two factors can further work to suspend tensions in what we term unitary spaces. Our theoretical model is depicted in Figure 1.

Compartmentalization Gives Rise to Data-Induced Rationality. In the case of organizations that we studied, the development and operation of data-intensive technologies were delegated to a specialized unit with a significant degree of autonomy. This is not surprising given that all but one of the case companies viewed digital technologies to be new, uncertain, and relatively distant from their established knowledge bases. These units were tasked with not only managing the data exchange with partners and the related operations but also, further developing these new capabilities. Accordingly, the units generally held a strong mandate to create utility for the partner, detaching the digital efforts from the broader economic goals of the organization. As a consequence of compartmentalization, the units had a narrow set of goals related to the exploitation of data-intensive technologies for the benefit of the partner company. Our findings illuminated how compartmentalization can facilitate the formation of a data-driven mindset. The narrow goals enable digital units to largely ignore considerations that do not immediately relate to the interorganizational routines involving partner organizations. As a result, digital units can conceive their own activities through the digital data created in the collaborative relationship.

The extensive real-time transfer of sensor data helps focus attention to the aspects of routines that can be captured and represented with digital data. Although digital data flows only "capture" reality imperfectly along predefined dimensions, the combination of extensive data flows and narrow goals means that an organizational unit can believe digital data flows to fully represent all the relevant aspects of its task domain. In such cases, digital indicators do not merely direct employee attention (Orlikowski and Scott 2014) but capture it in a way that made complementary human observation appear unnecessary. A *data-driven mindset* arises from a comprehensive set of technological affordances that crowds out employees' attention to observations and actions that fall outside those affordances. After individuals come to use the digital technology as the sole medium through which they make sense and interact, choices that arise in relation to the tasks at hand can be addressed through structured analysis of digital data. Consequently, the units conceived their mission as system optimization—minimizing resource use, human work, and emissions while maximizing equipment uptime and performance.

This data-driven mindset directed the digital units to develop *data-driven interactions* with the partner organizations. The exchange of data can facilitate the development of a shared and seemingly objective view of the collaboration. As our analysis shows, the data do not merely display the current and desired state of interorganizational processes, but they can also represent unambiguous and urgent paths for interaction in areas where operations deviate from the perceived optimum. Such urgent "flaws" in the task domain form a basis for targeted problem-solving responses among operational-level employees, in many cases triggered and guided by the software systems. Because the data-driven interactions are structured by a digital representation of the task domain and guided by technical rationality, employees can frequently make decisions involving the partner without oversight from their superiors. When collaboration is premised on the data-induced objectified view of tasks, collaborating units' focus is more likely to be constrained on emerging issues that can be rapidly fixed without managerial involvement. Such a "flow" of well-structured problem situations triggered by software can help maintain and even reinforce the compartmentalized nature of digital collaboration.

Data-induced rationalities emerge from comprehensive application of data-intensive digital technologies that do not merely afford certain ways of thinking and acting in the relationship but provide the employees with a coherent understanding of the tasks at hand. The relationships we observed used automatically generated sensor data that provided what our informants considered to be an objective representation of the key routines and processes. Data were not merely a virtual approximation to be verified by the reality as in the case of simulations (Bailey et al. 2012) but in a sense appeared as "hyperreal"—the dashboards and analyses were conceived as more accurate depictions of the operations than could be created through human observation and conversations.

Unitary Spaces as Outcomes of Compartmentalization and Data-Induced Rationality. Our analysis revealed the focus of digital collaborative units we studied on collaborative short-term benefits while effectively ignoring the competing demands imposed by long-term and private considerations. We use the term *unitary spaces* to denote such organizational units or domains that engage in single-minded pursuit of specific narrow goals while ignoring structural tensions and related competing demands. Unitary spaces are meant as an opposite to "hybrid spaces" that were recently theorized by Perkmann et al. (2019, p. 311) as "organizational subunits in which both the dominant and minority logic apply"—where organizational members attend simultaneously to competing and partially contradictory demands. Unitary spaces represent conditions where work is governed by an unchallenged focus on a set of convergent principles, a coherent "logic." In our case organizations, unitary spaces were not designed as deliberate responses to complexity and competing demands, but they emerged as unintended by-products of organizational compartmentalization and a compelling data-induced rationality.

Organizational compartmentalization appears to be a necessary, but not sufficient, condition for the formation of unitary spaces. Compartmentalization decreases interactions with other units, thereby shielding its members from diverse demands and political pressure from actors pursuing conflicting goals. Even without direct demands from other units, however, it is unclear why subunits would be oblivious to structural tensions that are arguably ubiquitous in collaborative relationships in particular (Das and Teng 2000, Im and Rai 2014) and in organizational life more generally (Putnam et al. 2016). Our analysis suggests that these unitary spaces were effectively maintained by the data-induced rationalities.

The data-driven mindset and interactions can focus attention of subunits on the immediate concerns, captured by data flows, so that the longer-term considerations are effectively "bracketed" outside employees' attention. In other words, the data-driven rationality provides "blindfolds" that make members of the organizational unit ignorant of any unmeasured, potentially competing demands. The coherent mindset and tool kit of interaction practices help focus the members' attention to short-term and collaborative objectives and legitimize this narrow focus as appropriate and sufficient.

Data-Induced Rationalities

Our findings contribute to the growing literature investigating and theorizing the impact of data and algorithms on organizing (Zammuto et al. 2007, Bailey et al. 2019, Kellogg et al. 2020) by elaborating how technologies for creating, transmitting, and analyzing sensor data fostered a data-driven rationality in industrial partnerships. Our choice of the term "rationality" seeks to capture this encompassing and "totalizing" effect of technologies that go beyond mere affordances (Cabantous et al. 2010). Although cognitive schemes represent domain-specific "subjective theories derived from one's experiences" and "mental maps which enable individuals to traverse and orient themselves" (Harris 1994, p. 310), the sociological conception of rationalities additionally alludes to the normative ideals and various material practices available to the actors. This is exemplified by the study of Foucault (1977) of shifting rationalities in penal institutions, where he argued that the shift from "retribution" to "correction" was driven by available tools: new theories and techniques in criminal psychiatry. A rationality is thus a pragmatic system of thought and action that directs how actors define issues and assess solutions.

The data-induced rationality we witnessed resonates strongly with the performative views of rationality (Cabantous and Gond 2010). This sociological strand of research has sought to bridge the normative-descriptive barrier, suggesting that rationality is an accomplishment enacted by purposeful agents, such as decision analysts (Cabantous et al. 2010). In our case, however, the data-induced rationality was not maintained merely by continuous human effort to enact rational technologies (Cabantous et al. 2010) but crucially by technological systems that governed and directed human practice. Moreover, the rationality was not premised on economic theory, as suggested by Cabantous and Gond (2010), but rather, on a more generic engineering mindset and mathematics of optimizing. Indeed, information systems appear to be making it increasingly effortless for employees to conceive and perform their tasks according to the rationality inscribed to these systems; rationality is an accomplishment of software systems rather than human analysts. The pursuit of optimization, guided by machine-generated data, has an air of objectivity that likely exceeds that of even the most legitimate theories.

The concept of data-induced rationality can further add to the existing understanding of virtual and data-based work, algorithmic evaluation, and technologies of accounting in organizations by elaborating how sensor data and their algorithmic analysis can become deeply entangled with human understandings (Orlikowski and Scott 2015). This is not merely material entanglement with information systems or interpretative entanglements of meanings through computer-mediated information; the entanglement involves individual agency becoming both motivated and mediated by data. Sensor technologies can establish the goals of human practice—the optimization of outputs as they are captured by sensors—and the means to enact them. The received literature has tended to study evaluations and accounting systems that are essentially separate from the practices they assess; the performative effects of algorithmic evaluation (Orlikowski and Scott 2014) and monitoring (Curchod et al. 2020) are controlled and carried out by distinct evaluators, whereas the prospective rituals of qualification through budgeting (Mazmanian and Beckman 2018) are temporally distant from the practices they engender. In contrast, practices involving sensor data incorporate the evaluation or "accounting" as an integral part of the ongoing work; algorithmic evaluations of human practice are created concurrently with work and available to the workers. In the case relationships we studied, the digital data did not only capture, account for, and shape human work, but the human work itself was designed and rationalized around digital representations of the sociotechnical systems. The big data systems we observed went beyond the mutual construction of accounting and organizing as distinct activities (Miller and Power 2013)—the very practices of collaboration were designed to produce their own evaluations through continuous generation of data.

Unitary Spaces and the Suspension of Tensions

The second contribution of our study relates to organizational spaces that shape how organizations manage competing demands and structural tensions (Greenwood et al. 2011, Perkmann et al. 2019). Unitary spaces represent a form of structural differentiation that shields activities from competing demands, sometimes associated with distinct institutional logics (Greenwood et al. 2011). In our case, the local suspension of tensions we observed was partially unintentional. Although digital services units were in part compartmentalized to enable distinct priorities (Duncan 1976, Tushman and O'Reilly 1996, Benner and Tushman 2003, Simsek 2009), the data-induced rationality further narrowed the focus of these units. Such effects of information systems provide a useful contrast to prior studies that have emphasized the deliberate efforts to separate activities through structural boundaries (Duncan 1976, Tushman and O'Reilly 1996, Raisch et al. 2009) and to integrate them through effortful practices (Greenwood et al. 2011, Perkmann and Spicer 2014, Perkmann et al. 2019, Smith and Besharov 2019). Unitary spaces also add to prior research on the effects of digital technologies on interorganizational governance and monitoring (Baker and Hubbard 2003, 2004; Curchod et al. 2020) and to innovation and learning (Boland et al. 2007, Lyytinen et al. 2016) by showing how information systems can shape employees' attention and goals.

Our analysis suggests three reasons that make digital units particularly likely to be compartmentalized and shielded from task interdependencies with other units (Thompson 1967). The digital services units in the manufacturing industry that we studied followed a distinct economic logic from most of the other units in the companies. The suppliers we studied were generally organized in business units with profitability goals, but none of their digital service units had clear profit-loss responsibilities. In case relationships Alpha, Gamma, and Delta, digital services were intended to make the company's products and services more attractive to customers, giving them a strong mandate for partner utility. Even more distinctly, in case relationship Beta, digital services were intentionally organized as a support function. The digital service units tended to be the only ones in the company with deep expertise in computer science or advanced statistics, forming strong disciplinary boundaries (Boland and Tenkasi 1995, Carlile 2002) that made their activities difficult for other managers to understand. Finally, top management in our case companies believed that the digital units should be more innovative and more customer oriented than other units, goals that they associated with greater autonomy. In effect, the compartmentalization seemed to be driven by management's recognition of digital activities as distinctively innovative (Yoo et al. 2010).

Unitary spaces explain how data-intensive technologies may induce short-term focus and reduce organizations' ability to productively juxtapose and integrate different temporal horizons (Slawinski and Bansal 2015). Because data-induced rationality draws attention to issues and solutions that can be depicted by data and addressed according to the logic of system optimization, it is likely to create myopia toward long-term outcomes that are more uncertain and more prone to political contestation (Kaplan 2008). Even when managers outside the unitary space are likely to attend to competitive and long-term outcomes, the relative disconnect from data-driven interactions is likely to polarize attention to short-term and long-term temporal horizons, thus making creative solutions to such tensions less likely (Slawinski and Bansal 2015).

Limitations and Future Research

Given our focus on five long-term buyer-supplier relationships in industries within the manufacturing sector, our study has important limitations. Foremost, the relationships we studied constitute but one prominent, but also particular, form of interorganizational relationship. The technologies we studied require large relationship-specific investments that are only to a limited extent redeployable to other relationships. As such investments require a long-term commitment and create durable interdependencies, they might not apply to triads, alliances, or networks.

Relatedly, all our case relationships were in heavy industry, with a strong engineering culture. Employees in such companies may hold an intrinsic interest in solving problems and optimizing processes. Data-induced rationality seemed to appeal naturally to our interviewees, who seldom questioned the value of digital quantification or even the optimization logic itself. There is a need for further study to assess whether such dynamics apply to other domains. For example, although health data such as blood pressure and laboratory tests have long afforded patients and doctors ways to observe patients' health and to design, monitor, and assess health interventions, these data are far too sparse a representation of the patient to create an encompassing data-induced rationality that would control doctor-patient interactions. Will data at some point provide such an encompassing representation of the human health and provide the sole medium for understanding the patient? In this vein, future research could examine boundary conditions for technological affordances to evolve into data-induced rationalities and explore other settings where the production or consumption of products or services becomes digitally mediated. Moreover, research could examine other effects of data-induced rationality beyond the suspension of structural tensions.

It is somewhat unclear to what extent the new technologies reshaped organizational priorities and ideals and to what extent the technologies simply reproduced and reified preexisting ideals (Orlikowski 1992). Sociology and organization theory have examined coherent rationalities (Foucault 1977; Townley 2002, 2008) and institutional logics (Friedland and Alford 1991, McPherson and Sauder 2013) as historically accumulated cultural structures related to specific fields. It remains for future research to assess whether digital technologies can provide such powerful sets of affordances that they induce their own compelling rationalities within and across organizations' units or whether the organizations we investigated adopted these technologies because they aligned with and supported the existing priorities and the engineering ethos.

Finally, it remains for future research to fully investigate the advantages and disadvantages of unitary spaces. Although it is possible that greater attention to long-term outcomes and competitive concerns in units we studied might have led to superior performance, these hypotheticals are difficult to assess. Our interviews show that both lower-level management and higher-level management were often aware of these competing concerns outside the immediate vicinity of digitally mediated collaboration but lacked either motivation or ability to react to them. Furthermore, our study was not able to quantify the potential benefits that accrued from the data-induced interactions and the related shared conception of interorganizational routines that the partnering companies created. Future research is needed to explore how unitary spaces affect interorganizational collaboration processes over time.

Concluding Remarks

Our study revealed how the compartmentalization of data-intensive technologies into specialized units induced a strong coherent data-induced rationality at the interface of collaborating companies, turning these units into "unitary spaces" that suspended structural tensions. Compartmentalized and data-infused work contexts can make employees oblivious to broader demands and tensions that cannot be captured in data flows. Although our study is set in the context of big data technologies in interorganizational collaborations, we believe it has important broader implications on digital quantification and smart algorithms in organizations. Organizational scholarship has increasingly recognized the impact of algorithmically generated indicators and evaluations on employees and entrepreneurs (Orlikowski and Scott 2014, Curchod et al. 2020, Kellogg et al. 2020), drawing attention to data as a reified and arbitrary but highly legitimate aspect of organizational reality (Mazmanian and Beckman 2018). Our study adds to this stream of literature by showing how comprehensive sensor data can induce a coherent understanding of the actors' setting, their role, tasks at hand, and possible courses of actions. Sensor technologies can thus lead to a "digital first world" (Baskerville et al. 2020), where the digital representations of the task domain precede and guide organizational practices rather than merely capturing and supporting them. Studying these effects is vital, particularly as many managers may have limited understanding of the data-intensive technologies that increasingly shape how organizations conceive and address opportunities and problems.

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