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DIGITAL STRATEGIC INITIATIVES AND DIGITAL RESOURCES: CONSTRUCT DEFINITION AND FUTURE RESEARCH DIRECTIONS[1]

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This paper explores the structure and design of digital strategic initiatives (DSI): identifiable competitive moves that depend on digital resources to create and appropriate economic value. We use the term digital deliberately, in line with the recent push for discerning the so-called IT "x" and Digital "x" phenomena. The paper contributes to basic science by precisely defining the digital strategic initiative concept and its essential elements: digital resources. It clarifies the difference between digital resources and established constructs such as IT resources and IT-enabled resources. We posit that the defining characteristics of digital resources are their modular design, encapsulation of value, and programmatic interface. This work also shows how the design and development of digital strategic initiatives thrive in an infrastructural, combinatorial, and servitized environment. Using illustrative cases, we demonstrate applications of the concepts by introducing two value creation pathways for DSI: (1) orchestration of digital resources and (2) creation of novel digital resources. The paper concludes by presenting open research questions and offering extensions for future inquiry.

Keywords: Digital resources, digital strategy, digital innovation, IT resources, IT strategy

> *"I don't see any other payment companies thinking about payments as an API problem, as software problem, or an infrastructure problem. We look much more like Amazon Web Services than any traditional payment company."*
>
> --John Collison, Co-founder and President, Stripe Inc. (Collison, 2017a)

Introduction

What is a Digital Strategic Initiative (DSI)? How does it differ from a generic strategic move or an IT-enabled strategic initiative? How can DSIs be designed and implemented by organizations intent on creating and appropriating economic value? These questions are central to the information systems (IS) literature because they contribute to our collective understanding of digital strategy and digital innovation. They are particularly important today because the way digital

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technology enables and shapes a company's strategic initiatives has profoundly changed (Bharadwaj et al., 2013). Exposing the lack of clarity on the topic, scholars have pointed to the proliferation of Digital "x" constructs (e.g., digital infrastructure, digital innovation) that parallel well-established IT "x" constructs (e.g., IT infrastructure, IT innovation) (Baiyere et al., 2017; Rodriguez & Piccoli, 2018). They have called for rigorous investigation based on sound ontology (Faulkner & Runde, 2019), lamenting that the literature has yet to explain *what* has changed and *why* (Baiyere et al., in press).

We respond to these calls by addressing the theoretical gap in the specific context of strategic initiatives and digital strategy. We conceive of *digital strategic initiatives* as identifiable competitive moves that depend on the use of *digital resources* to create and appropriate economic value (Piccoli & Rodriguez, 2020). Our intent is to provide the ontological foundation necessary to extend the digital strategy agenda along three lines of inquiry: DSI design and implementation, organizing for DSI, and DSI strategic outcomes. Our work explicitly clarifies the difference between the digital resource construct and traditional conceptualizations of information technology (IT) resources (Melville et al., 2004; Wade & Hulland, 2004)[2] and IT-enabled resources (Nevo & Wade, 2010). Importantly, our definition of digital resources does not supersede, but rather complements, the traditional definition of IT and IT-enabled resources. Thus, while IT capabilities, such as systems integration and project management (Melville et al., 2004), remain critical for DSI design, implementation, and management, digital resources go beyond the confines of the IT function. As the digitization of everyday experiences continues (Yoo, 2010) and software "programs the world" (Andreessen et al., 2016), they encompass an ever-increasing array of strategic, organizational, and social phenomena (Greeven et al., 2021). Our conceptualization of digital strategic initiatives and digital resources serves as a contribution to basic science, bringing definitional precision to labels gaining currency in the academic and managerial discourses, while enhancing the value of information systems as a reference discipline.

The paper is organized as follows: The next section grounds the work in the extant literature by first demonstrating the failure of IS literature to articulate the nature of digital resources and then reviewing key concepts from the strategic IS tradition that underpins our theorizing. This is followed by a formal definition of the DSI construct and the role of digital resources at its core. The paper then clarifies the defining characteristics of digital resources in relation to traditional IS constructs. The following section details the infrastructural, combinatorial, and servitized characteristics of the environment that foster the development of digital resources and DSIs. The subsequent section illustrates the concepts with four cases and introduces two value creation pathways for DSI: (1) orchestration of digital resources, and (2) creation of novel digital resources. The paper concludes with a discussion, and a set of questions and propositions guiding future research directions.

Related Literature

The premise of our theorizing is that the crafting and consequences of digital strategic initiatives depend upon the ontological nature and design of digital resources at their core. Recent research suggests that *digital* initiatives are defined by their focus on the customer (Tumbas et al., 2018). Yet, customer facing *IT-enabled* initiatives have been core to strategic IS research for decades (Ives & Learmonth, 1984). Similarly, *digital* transformation is distinguished from *IT-enabled* organizational transformation in terms of organizational motivations and outcomes (Vial, 2019; Wessel et al., 2021). But it is legitimate to ask: *What warrants the change in terminology if there is no change in the nature of the underlying resources?*

Foundational Concepts

Resources play a central role in the business value of IT literature (Melville et al., 2004), both in the search for IT-enabled value creation (Wade & Hulland, 2004) and the role that digital technology plays in sustained competitive advantage (Piccoli & Ives, 2005). Organizational resources are "assets and capabilities that are available and useful in detecting and responding to market opportunities or threats" (Wade & Hulland, 2004, p. 109). Assets are "anything tangible or intangible the firm can use in its processes for creating, producing, and/or offering its products (goods or services) to a market" while capabilities are "repeatable patterns of actions in the use of assets to create, produce, and/or offer products to a market" (Wade & Hulland, 2004, p. 109). Traditionally, IT assets have been associated with digital hardware and software (e.g., IT infrastructure, information repositories), whereas IT capabilities stem from human and organizational competencies (e.g., IS-business partnership, software development skills). IT-enabled resources are those systems emerging from "a relationship between an IT asset and an organizational resource" (Nevo & Wade, 2010, p. 169). While this focus was appropriate in a context dominated by hardware and software

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[2] While the literature refers at times to IT resources and other times to IS resources, an exploration of the difference is beyond the scope of our work. For the remainder of the paper, we use "IT" to denote IT/IS resources, IT/IS assets and IT/IS capabilities.

assets that were largely "IT boxes" (Baiyere et al., 2017) implemented within organizational boundaries, pervasive digitalization continues to challenge traditional pathways of value creation (Tilson et al., 2010; Yoo et al., 2010).

Digital resources are emerging as a critical construct for explaining "digital phenomena." Recent research goes so far as to suggest that digital resources should be a focal unit of analysis for digital innovation research (Henfridsson et al., 2018). However, this and other works (Faulkner & Runde, 2019; Kohli & Grover, 2008; Lusch & Nambisan, 2015) stop short of providing a first principled definition of the digital resource construct, one that builds on previous IS research while drawing essential differences with the traditional conceptualization of IT resources and IT-enabled resources (Baiyere et al., in press; Faulkner & Runde, 2019). Such clarity is necessary to investigate the structure and design of DSI and to advance the digital strategy agenda.

Current Use of Digital Resources in the Literature

Previous literature has suggested that digital resources have unique characteristics, such as editability (Kallinikos et al., 2013), reprogrammability (Yoo et al., 2010), and product agnosticism (Henfridsson et al., 2018). Yet these are also characteristics of traditional IT resources, such as software programs or data. Definitional ambiguity stems from the fact that most contributions using the digital resource construct fail to explicitly define it (Table 1). Those that do offer a definition typically describe them as leveraging a digital technology core, making it difficult to draw a distinction with traditional definitions of IT resources. Seminal IS literature describes IT as "the technology needed to transform inputs to outputs" (Bostrom & Heinen, 1977, p. 17) and IT artifacts as "those bundles of material and cultural properties packaged in some socially recognizable form such as hardware and/or software" (Orlikowski & Iacono, 2001, p. 121). The hardware and software of interest to IS scholars have always been instantiated as the elements of digital computer systems (i.e., a digital technology core). Leveraging a digital technology core is therefore not distinctive, thus leaving "a lot to be theorized on how digital operates differently [than IT]" (Baiyere et al., in press).

We argue that the introduction of a new term (i.e., "digital") requires a recognizable change of material import that engenders qualitatively different phenomena (Leonardi, 2010). By engaging with the structural characteristics of DSIs and digital resources, we seek to advance conceptual clarity and highlight the distinctive nature of novel digital strategy phenomena (Grover & Lyytinen, 2015).

Digital Strategic Initiatives

The strategic information systems literature defines IT-dependent strategic initiatives as "identifiable competitive moves that depend on the use of IT to be enacted and are designed to lead to sustained improvements in a firm's competitive position" (Piccoli & Ives, 2005, p. 748). They consist of the configuration of an activity system, dependent on IT at its core, that fosters the creation and appropriation of economic value. Similarly, we propose that digital strategic initiatives (DSI) are identifiable competitive moves that depend on the use of *digital resources* to create and appropriate economic value (Piccoli & Rodriguez, 2020). This definition addresses both the structure (what is) and function (what it does) of DSIs. Each element of the definition is contextualized below.

Initiative

An initiative is an action, a "new plan for dealing with a particular problem or for achieving a particular purpose" (Oxford University Press, n.d.). In the context of organizational strategy, an *initiative* is a competitive action or response a firm takes to improve its position in the market (Smith et al., 1991). Competitive moves encompass a large swath of efforts, ranging from simple one-time actions (e.g., Apple cutting the price of the iPhone 13) to complex long-term initiatives (e.g., Space X offering interplanetary transportation). Not all initiatives, however, can be considered strategic.

Strategic

The ultimate objective of business strategy is to help a firm achieve sustained superior performance through the implementation of nontransitory decisions characterized by a high degree of reliability, commitment, and irreversibility (van den Steen, 2017). Thus, any successful *strategic initiative* must contribute to the firm's temporary monopolistic position and it must limit countering by competitors (Schumpeter, 1934). Of these two objectives, the first is achieved through value creation, classically defined as the difference between the customer willingness to pay commanded by the firm's product or service and the supplier opportunity cost of the resources used by the firm to create its offerings (Brandenburger & Stuart, 1996). The second results in value capture, the ability to appropriate a portion of the value created in the form of profits (Piccoli & Ives, 2005). It follows that strategic initiatives differ from tactical moves and strategic experiments. While strategic initiatives focus on value creation, tactical moves and strategic experiments do not directly impact either customer willingness to pay or supplier opportunity cost. Not all strategic initiatives are digital.

Table 1. Digital Resource Conceptualization in Existing Literature

Concept	Definition	Treatment of the digital resource construct	Differentiation from IT "x"
Digital innovation	Digital innovation is defined as "the carrying out of new combinations of digital and physical components to produce novel products" (Yoo et al., 2010, p. 725).	Digital components (i.e., IT) afford the design and implementation of digital innovation in the context of physical products. Examples used in the paper include GPS and social media applications.	Since digital components are not formally defined, it is difficult to see the difference from IT components.
Digital business strategy	Digital business strategy is defined as "organizational strategy formulated and executed by leveraging digital resources to create differential value" (Bharadwaj et al., 2013, p. 472).	Digital resources are constitutive elements (components) of digital business strategies, conceptualized as those resources that incorporate any digital technology (e.g., Amazon Web Services).	The nature of digital is not addressed, and focusing on "any digital technology" evokes similarity to IT as historically defined.
Digital infrastructure	"Digital infrastructure as the collection of technological and human components, networks, systems, and processes that contribute to the functioning of an information system" (Henfridsson & Bygstad, 2013, p. 908).	Digital resources (technical components) form the foundation of digital infrastructures. Examples include enterprise service bus (ESB), booking systems, and Internet portals.	Digital resources are not formally defined, and their description as technical components makes it difficult to see their distinctiveness from IT as historically defined.
Digital service platforms	Service platform: "a modular structure that comprises tangible and intangible components (resources) and facilitates the interaction of actors and resources (or resource bundles)" (Lusch & Nambisan, 2015, p. 166).	While digital resources (components) are conceptualized as a critical component of service platforms, their nature is not addressed.	Digital resources are not formally defined, with the implication that any resource using IT is digital and that digital resources are no different than IT resources.
Digital platform	Digital platforms are defined as "a set of digital resources—including services and content—that enable value-creating interactions between external producers and consumers" (Constantinides et al., 2018, p. 381).	Digital resources are a defining element of digital platforms. Examples of digital resources used in the paper include APIs and SDKs.	While the examples hint at the importance of technical and governance elements of digital resources, there is no discussion of their differences with IT resources.
Digital resources	Digital resources are defined as "entities that serve as building blocks in the creation and capture of value from information in digital innovation. A digital resource (1) belongs to a specific value space, (2) has the potential to simultaneously be part of multiple value paths, and (3) is typically product-agnostic" (Henfridsson et al., 2018, p. 92).	Digital resources are critical components for digital innovation. The definition focuses on digital resources in use and clarifies the scope and role of digital resources in multiple innovations thanks to their product agnosticism.	The definition does not directly clarify the nature of digital resources and how they differ, if at all, from IT and IT-enabled resources.

Digital

Our focus is on strategic initiatives that could not feasibly be implemented by the firm without a core of digital resources. As used here, the term "digital" signals a substantive departure from the terms "IT-dependent" (Piccoli & Ives, 2005) or "IT-enabled" (Nevo & Wade, 2010).

Digital Resources

To conceptualize digital resources, we start by defining their fundamental unit, the digital object. We then describe digital resources as a specific class of digital objects that (1) are *modular*, (2) *encapsulate objects of value*, namely assets and/or capabilities, and (3) are accessible by way of a *programmatic interface*. We devote the remainder of this section to reviewing the ontology of digital objects, introducing the theory of modularity, exploring the ontology of digital resources, and delineating attributes that differentiate them from traditional IT resources.[3]

Digital Objects

An object is an enduring structured collection of elements, a "structured continuant" (Faulkner & Runde, 2013). Objects persist through time during their existence and are comprised of distinct components (also objects) organized in a discernible arrangement. Objects that exhibit spatial attributes are material objects (e.g., an iPhone's touch screen), while those that do not are nonmaterial objects. Digital objects are those "whose component parts include one or more bitstrings" (Faulkner & Runde, 2019, p. 1285). Bitstrings, separated in program files and data files, are "the sequences of 1's and 0's used in computing to represent information in binary form" (Faulkner & Runde, 2013, p. 804).[4] While it is tempting to treat any form of IT as a digital object, such interpretation is incorrect. Specifically, digital electronics and hardware components, such as the Google Tensor Processing Unit (TPU) integrated circuits or Apple's iPad magic keyboard, are not digital objects, but they are indeed IT.[5] Nonmaterial objects (e.g., a poem, music) need a physical bearer (e.g., a notebook, sheet music). Bitstrings always need hardware as the material bearer of the lowest level, but hardware does not need software to exist. An important characteristic of the bitstring is that, despite being a nonmaterial digital object, it can serve as the bearer of other nonmaterial objects, including other bitstrings (Faulkner & Runde, 2013). This property underlies the digitization of content, procedures, algorithms, and know-how (Overby, 2008; Tilson et al., 2010). Finally, digital computer systems, hardware and software bundles like an iPhone running iOS or a laptop running Microsoft Windows, are hybrid digital objects comprised of both material and nonmaterial elements (Faulkner & Runde, 2013).

While providing sound ontology to ground the digital resource concept, the preceding definition of digital objects does not allow for differentiation between IT resources and digital resources. Any hardware/software system rooted in the von Neumann digital computer architecture and the stored program concept (von Neumann, 1945) is a hybrid digital object. Note, however, that as with the same-state polymorphism characterizing diamond and graphite, the same constitutive elements arranged in different structures can give rise to starkly different objects that exhibit different properties. We theorize digital resources as a specific class of digital objects that embody assets and capabilities and make them accessible programmatically. To clarify their ontology, we draw on the theory of modularity.

Modularity

Modularity represents "the degree to which a system's components can be separated and re-combined" (Schilling, 2000, p. 312). In the theory of modularity, a design architecture specifies the functional elements of a system and how they interact to deliver the system's functionality (Ulrich, 1995). Modularity is on a continuum; architecture and module designs that reduce the need for tight integration and promote the loose coupling of components increase a system's overall modularity (Schilling, 2000): "A module is a unit whose structural elements are powerfully connected among themselves and relatively weakly connected to elements in other units" (Baldwin & Clark, 2000, p. 63). Thus, modules are units in a larger system that are structurally independent of one another due to their design,

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[3] Note that the use of a new term does not imply it did not exist before its introduction. There are a few *ante litteram* examples of digital resources, such as those pioneered by Salesforce (as discussed later in the paper).

[4] As defined by Faulkner and Runde (2019), the term bitstring parallels the colloquial use of the term software, encompassing data and program files. Thus, we treat them as synonyms in this paper.

[5] Hardware, the physical component of a computer system, is definitionally distinct from bitstrings (i.e., software). A potential point of confusion is that many modern IT products classified as hardware, do indeed contain software elements and are therefore hybrid digital objects. A modern printer or a solid-state disk (SSD), colloquially referred to as hardware components, encompass controllers and software. Thus, akin to smart speakers and unlike a mouse or an SD card, they are more accurately classified as digital objects rather than hardware.

which enforces information hiding (Parnas, 1972) through abstraction (Baldwin & Clark, 2000) and encapsulation (Schilling, 2000). By design, a module's internal design architecture, whether highly integrated or modular itself (Tiwana, 2018), is not visible to other modules, thus minimizing interdependencies between modules.

Encapsulation enables information hiding by ensuring that modular components interact with the other elements in the system's design architecture strictly through their interface, thus not needing visibility into the module's inner workings (Schilling, 2000). The interface is the "preestablished way to resolve potential conflicts between interacting parts of the design" (Baldwin & Clark, 2000, p. 73). Therefore, "modular components[6] are components whose interface characteristics are within the range of variations allowed by a modular product architecture" (Sanchez & Mahoney, 1996, p. 66). Modular component design ensures that the reuse and recombination of a module are handled systematically through its interface. They do not entail ad hoc integrations or substantial coordination between the module creators and the organization crafting a new design that uses the component. The technical aspects of artifact design (e.g., design rules and task structure) are accompanied by an explicit or implicit contract structure[7] that provides the framework for organizational activities within the design hierarchy (Baldwin & Clark, 2000).

One classic example of modular design, the IBM System 360, illustrates these concepts. The IBM SPREAD task group in charge of System 360's design architecture revolutionized the computer industry by pioneering the efficient separation of effort and knowledge requirements for computer system design and production. Because of its modular architecture, IBM's System 360 gave momentum to modular component designers, the original equipment manufacturer (OEM) industry as we know it today. The design architecture of System 360 exposed design rules to manage the interdependencies between modules. Therefore, independent OEMs could compete to produce modular components compliant with the interface requirements (e.g., 12-pin chips for plugging into the backplane). In turn, information hiding enabled IBM to evaluate the potential for inclusion of each modular component based on its performance characteristics rather than its internal design.

Definition of Digital Resources

Drawing on the ontology of digital objects and the theory of modularity, we conceptualize digital resources as a specific class of digital objects that (1) are *modular*; (2) *encapsulate objects of value*, assets, and/or capabilities; (3) and are accessible by way of a *programmatic interface*.

Modular: Digital resources are digital objects designed to work as units in larger systems. They are *modular components*, regardless of whether their internal structure is itself modular or monolithic. For example, Instacart orchestrates a set of digital resources (e.g., Stripe Payments, Twilio messaging and communication) into a value creating DSI—grocery delivery within a two-hour delivery window. Instacart incorporates Stripe's payment capabilities as a module without any visibility into its internal structure. Like any modular component, digital resources can be recursively composed of other digital resources (Ulrich, 1995). Stripe leverages digital resources, such as AWS EC2 compute and S3 storage, to produce the digital payment resource that customers like Instacart or Ford use in their own DSIs.

Encapsulate objects of value: Faulkner and Runde (2019) show that the ability to bear objects of value "is arguably the single most important feature of the bitstring [leading to the conclusion that] the demand for bitstrings is a derived one" (p. 1293). Similarly, a digital resource has no intrinsic value separate from the demand for the asset or capability it encapsulates. In the context of DSIs, valuable resources are those that are instrumental to the firm's ability to create value. Organizations using the Stripe Payments module in their DSI can access the valuable capability to process payments encapsulated in Stripe Payments and do not have to develop their own internal payment competence to transact with customers.

Accessed via programmatic interface: Digital resources are accessed via a programmatic interface rather than a manual or physical interface.[8] Access is fully managed by a software boundary that exposes the encapsulated asset or capability via a set of prespecified data elements and request-response actions (e.g., JSON files, API calls). Note that the digital resource is a digital object, a "cohesive whole," of which the interface is a constitutive element.[9] It follows that a digital resource's programmatic interface not

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[6] The term "modular" can be confusing when referring to a system's component rather than the overall system's architecture. In this use, the term does not imply that the module has an internal modular architecture. Instead, it means that the "modular component" performs as a module within a larger system architecture (Schilling 2000).

[7] In the theory of modularity, the contract structure describes "the set of contracts used to form a collective enterprise, and to organize its dealings with the greater economic environment" (Baldwin and Clark 2000 p. 107).

[8] Strictly speaking, digital resources have a programmatic *bitstring* interface. We use the shorthand "programmatic interface" throughout because in the context of our work the term "programmatic" is understood to imply algorithmic digitality (i.e., implemented as a bitstring).

[9] There is increasing research attention devoted to "API strategies" (Davenport and Iyer 2013; Iyer and Subramaniam 2015). Unfortunately, the term is often loosely defined, leading to conflation with the concept of

only encompasses a set of technical specifications (e.g., RESTful APIs access controls via tokens, rate caps, throttling of service requests) to make use of the encapsulated object of value (e.g., data objects in a database), it also covers the contract structure and coordination mechanisms (Baldwin and Clark 2000) that govern programmatic access to the resource (e.g., per-use or bulk billing, enforcement of service level agreement or regulatory frameworks). Thus, a digital object configures as a digital resource when it inscribes in its programmatic interface both the technical and governance specifications for resource access and use.

Following the above reasoning, we can categorize digital assets and digital capabilities based on the characteristics of the encapsulated object of value. *Digital assets* are digital resources that encapsulate either nonmaterial digital objects, such as a catalog of digital songs, or hybrid digital objects, such as a virtualized computing resource. *Digital capabilities* are repeatable patterns of organizational actions yielding a capacity to undertake activities that a firm can access programmatically through a programmatic digital interface. By definition, digital assets and digital capabilities are modular components. They may configure internally as either nonmaterial or hybrid digital objects. Their use, reuse, and recombination in novel DSI designs occur via a nonmaterial interface encoded in software—the programmatic bitstring interface. Recent research refers to this concept as “resource liquefaction …, the decoupling of information from its related physical form or device” (Lusch & Nambisan, 2015, p. 160).[10] Our work explains *why* “resource liquefaction” is possible and describes the *structure* of “liquefied” resources. That is, when a digital resource is recombined into the design architecture of a DSI, other components in the design must interface with it as a nonmaterial digital object. Abiding by the technical and governance specification of the programmatic interface, the DSI designer can leverage the digital resource exclusively via its digital abstraction—irrespective of whether the resource is internally a nonmaterial or hybrid digital object. It is this unique characteristic that warrants labeling these resources as *digital*.

Digital Resources, IT Resources, and IT-Enabled Resources

The information systems literature categorizes IT resources into IT assets, such as hardware, IT infrastructure, or software applications (Melville et al., 2004); and IT capabilities, such as IT skills or IT management abilities (Wade & Hulland, 2004). It further recognizes IT-enabled resources as hybrid digital objects with emergent capabilities stemming from the synergistic combination of IT assets and organizational resources (Nevo & Wade, 2010).

The creation of a digital resource is an act of design, and many digital resources are designed ex novo. However, any IT resource or IT-enabled resource can be rearchitected to configure as a digital resource. This redesign process illustrates the relationship between IT “x” and Digital “x” constructs (Figure 1) and we use it in the remainder of this section.[11]

IT Assets and Digital Assets

The literature views IT assets as hardware or software, data, and programs within the organization’s control. Hardware assets are not digital objects; to constitute a digital asset, they must first evolve into hybrid digital objects. TPUs are at the heart of the Google Cloud TPU service that allows clients to train machine learning models on dedicated hardware optimized for ML tasks. Clients provisioning TPUs can do so because the hardware has been virtualized into hybrid digital objects using dedicated software (e.g., hypervisors). Such virtualized IT assets configure as digital assets when they are modularized and exposed through a programmatic interface that embeds technical and governance specifications for their use. Compute and storage resources configured as digital assets are now common in the offerings from major infrastructure-as-a-service providers (e.g., AWS EC2). They are the prototypical examples of hardware IT assets rearchitected into digital assets.

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resources. APIs are specifications, in the form of routine definitions, protocols, and tools, for programmatic access to an application’s functionalities or data. APIs, a popular approach to implementing the interface of digital resources, are therefore a key constitutive element of the resource, not a synonym.

[10] In this view “liquefaction” loosens the coupling between the bitstring elements of the resource and their physical bearers (e.g., a DVD player needed to enjoy a movie experience), with the latter no longer central to the resource’s value proposition.

[11] As we mentioned earlier, there are *ante litteram* examples of digital resources. In 2000, Salesforce was one of the first enterprise software companies to create value by exposing valuable resources through a bitstring programmatic interface, using an XML API. Recognizing that data typically locked away in CRM software (e.g., product images, preferred customer greeting or communication method) could be leveraged by their clients for multichannel communication (e.g., email communication, website personalization, mobile texting), Salesforce sought to facilitate the recombination and repurposing of such valuable data by clients. It did so by rearchitecting those assets, encapsulating and exposing them through a digital interface. Consistent with our terminology, the firm referred to these rearchitected IT assets as *digital* assets.

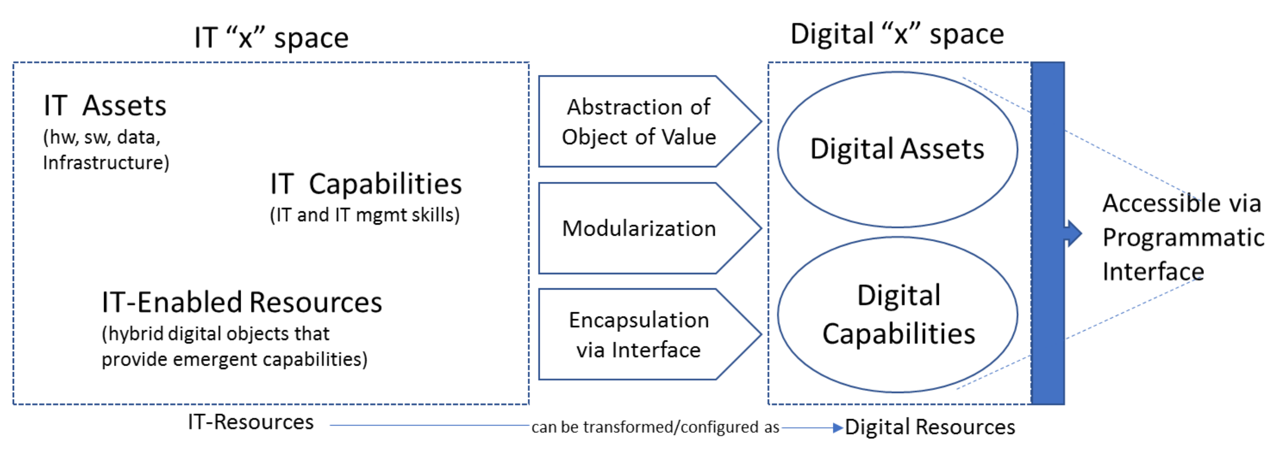

Figure 1. IT Resources, IT-Enabled Resources, and Digital Resources

Traditional IT assets also include data and software applications (Melville et al., 2004). As nonmaterial digital objects, both data and software programs can be directly rearchitected as digital assets when modularized and exposed through a programmatic interface. The recent emergence of data exchanges shows how data repositories, a type of IT asset (Piccoli & Ives, 2005), are being reconfigured as digital assets. Firms like Snowflake promise to deliver "instant elasticity, secure data sharing and per-second pricing, across multiple clouds" (Snowflake, 2019). Traditional data sharing requires a data provider to transfer IT assets (e.g., datasets) via an ETL process into the consumers' own IT infrastructure. Such ad hoc manual integration of the data providers' assets into the consumers' own data stores is a prerequisite to data processing and analysis. Data exchanges increase data liquidity (Wixom et al., 2021) by architecting data assets as modular objects of value encapsulated by a programmatic interface (Moyano et al., 2020). Using Snowflake technology, for example, a data provider can expose specific digital data assets to the applications of authorized data consumers who need not download and integrate the data into their own data warehouse or operational data stores. Rather, they access a single up-to-date copy of the data via a programmatic interface that manages the technical elements of the transaction and enforces governance rules like data deidentification, access restrictions, and use rights (Wixom et al., 2021).

Software programs are IT assets when they are not modular and/or are not encapsulated in a programmatic interface. Many established software vendors are reconfiguring their software as digital assets. An example is the recent evolution of Microsoft Excel. With the release of the Graph API, Microsoft enables access to properly abstracted Excel software functionalities (e.g., net present value formula) via a programmatic digital interface. Note that the programmatic interface of the Microsoft Graph API not only specifies how to make atomic function calls, but it also encapsulates authentication, read and write permissions, license enforcement, and other governance specifications.

IT Capabilities and Digital Capabilities

The information systems literature traditionally defines IT capabilities as a specific type of organizational capability, such as IT skills or IT management abilities (Wade & Hulland, 2004). This definition was recently criticized as the source of an important research gap that ignores and marginalizes digital objects (Faulkner & Runde, 2019). The conceptualization of digital capabilities as modular repeatable patterns of actions exposed for external use via a programmatic interface helps fill the gap and broaden the scope of information systems research beyond mere IT capabilities by allowing a wide range of organizational capabilities and organizational routines to configure as digital capabilities (Greeven et al., 2021).

Digital capabilities can be fully abstracted as bitstrings, or stem from IT-enabled resources. Consider Stripe's digital payment capability. Without access to Stripe, a firm would need to develop its own payment collection for services rendered organizational capability. Historically, firms do so by using a combination of software (e.g., Quickbooks) and other organizational resources (e.g., account receivable clerks) to create and send invoices and track the payment of such invoices. Conversely, Stripe clients integrate the Stripe Payment capability as a software module into their own strategic initiatives, thereby leveraging such capability programmatically. Digital capabilities are the digital counterpart of organizational capabilities and IT-enabled capabilities. As such, even when instantiated as bitstrings, they differ from software programs that have been configured as digital assets. Digital capabilities embody repeatable patterns of organizational actions in the use of assets that provide the firm with the latent capacity to undertake activities (Table 2). They inscribe one or more organizational business processes as part of their object of value. When actioned,[12] such business processes produce value for the organization.

Unlike a software program or a digital asset encapsulating software functionality (e.g., Microsoft Graph API), a digital capability is a coherent, fully formed modular organizational capability exposed by way of a programmatic interface. In some cases, an organizational capability cannot be fully abstracted into bitstrings (i.e., fully inscribed in software). In this case, the digital capability stems from the modularization and encapsulation of an IT-enabled resource whose emergent capabilities are exposed for integration into a DSI through a programmatic interface. A good example is Stuart, the Paris-based creator of an on-demand delivery capability for restaurants. The capability emerges from the interplay of an organizational resource (i.e., delivery riders) and IT assets such as smartphones, dispatch algorithms, and messaging software. Stuart exposes the delivery capability through an API. Regardless of the internal configuration of the delivery capability, restaurants orchestrating a food delivery DSI can leverage it (e.g., dispatch riders) programmatically via the programmatic interface.

Digital capabilities do not conceptually supplant IT capabilities, they are structurally different. The former are digital objects encapsulating repeatable patterns of actions, whereas the latter are managerial and technical organizational competences. Thus, as defined here, digital capabilities call for the development of new IT capabilities. Table 3 summarizes construct definitions.

Digital Strategic Initiatives in Context

The main objective of DSIs, identifiable competitive moves that depend on the use of digital resources, is to enable value creation and appropriation by the implementing firm. As with any strategic initiative, its value generation potential is influenced by the environmental context in which it is introduced (Sambamurthy et al., 2003). Combinatorial technology evolution occurs when there is a critical mass of elements available for recombination and a mechanism for them to be recombined (Arthur, 2009). Thus, each new modular abstraction needs the appropriate infrastructure to support it and the presence of compatible and complementary modules to yield novel recombination (Henfridsson et al., 2018). The modular nature of the digital resources at the core of DSIs requires the existence of a digital information infrastructure (Hanseth & Lyytinen, 2010) of compatible components ready for recombination and the ability to servitize the resource by embedding both technical and governance specifications in the interface. We theorize that DSIs thrive in an *infrastructural*, *combinatorial*, and *servitized* environment and discuss each of the three environmental catalysts below.

Infrastructural

Infrastructures include the facilities and the basic physical and organizational structures for the operation of a society or enterprise (Oxford University Press, n.d.). The IT infrastructure of an organization is conceptualized as the foundation of the IT portfolio that enables the delivery of business applications and services (Broadbent et al., 1999). As IT leaves the boundaries of corporations to permeate virtually any aspect of society, in large part thanks to the global internet, localized and bounded IT infrastructures increasingly give way to digital information infrastructures—"unbounded, evolving, shared, heterogeneous, and open installed bases of capabilities" (Tilson et al., 2010, p. 754) configured as "sociotechnical systems comprising an installed base of diverse information technology capabilities and their user, operations, and design communities" (Hanseth & Lyytinen, 2010, p. 4). This definition highlights the recursive and shared nature of digital information infrastructures. They are sociotechnical artifacts (Silver & Markus, 2013) comprised of elements that nonexclusively contribute to the functioning of other information systems (Henfridsson & Bygstad, 2013). The mobile internet infrastructure, for example, is built recursively on the internet infrastructure (i.e., TCP/IP protocols, fiber backbone, networking hardware, globally distributed servers) and smartphone clients connected via cellular towers. It provides the shared underlying layer for a host of digital phenomena—including the availability of a digital resource like Stripe Payments. In summary, organizations can assume the widespread availability of shared, unbounded, heterogeneous, open, and evolving digital information infrastructures on which to envision and deploy value creating digital strategic initiatives.

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[12] The notion of "repeatable patterns of action" emphasizes *abstract patterns* not the actual sequence of actions in physical space. Thus, capabilities are latent until deployed. Tangible outcomes occur only when capabilities are "actioned" or enacted (Helfat & Raubitschek, 2018).

Table 2. Possible Configuration of Software Programs

	Modular	Interface	Business process	Examples
IT Asset	No	Human-computer interface	None	• Microsoft Excel • Adobe InDesign • Opera—Oracle's PMS for hotels
Digital asset	Yes	Bitstring programmatic	None	• Microsoft Graph API • Google Maps (Places API) • BBVA Accounts API
Digital capability	Yes	Bitstring programmatic	Embedded	• Amazon Connect • Stripe Payment • BBVA Auto Loan

Table 3. Construct Definitions

Construct	Definition	Example
Digital object	Enduring, structured collection of elements, whose component parts include one or more bitstrings.	Digital movies, blog posts, smart devices, autonomous cars, digital assets, and digital capabilities.
Digital resource	A specific class of digital objects that are modular, encapsulate objects of value, and are accessible by way of a programmatic interface.	Any digital asset or capability, such as Google Maps or online mortgage applications automatic credit scoring.
Digital asset	Those digital resources that encapsulate either nonmaterial digital objects or hybrid digital objects.	BBVA Accounts exposes, upon customer's authorization, client data, such as the account's currency, debits and credits transactions, statements, and the like
Digital capability	Those digital resources that encapsulate repeatable patterns of organizational actions, yielding a capacity to undertake activities.	BBVA Auto Loan enables potential customers to programmatically simulate, register, and receive an auto loan, thus offering the possibility of "instant financing."
Digital strategic initiative	Identifiable competitive moves that depend on the use of digital resources to create and appropriate economic value.	Any initiative leading to the creation of a digital resource or the orchestration of digital resources into a value proposition, such as Lyft ridesharing.

Combinatorial

Technological progress stems from the combination and recombination of evolving components into new structures, leading to a constant state of combinatorial technology evolution (Arthur, 2009). An important driver of combinatorial evolution in technology is the availability and variety of elements that serve as the building blocks of new structures, such that "the more there is to invent with, the greater will be the number of inventions" (Ogburn 1922, as cited in Arthur 2009, p. 21). Consequently, new sociotechnical components are constantly being added to the available universe by firms seeking to provide value through novel recombination. To cope with complexity, organizations partition problems into parsimoniously linked subproblems whereby complex systems can be managed by breaking them into smaller components (i.e., modules) with boundary interfaces that insulate the "internal environment" from the "external environment" (Simon, 1996). This is the process whereby "technology creates itself out of itself" (Arthur, 2009, p. 21). With each new layer of abstraction, the complexity of previous technological evolutions is hidden in a new module that is accessible to other modules by way of an interface (Baldwin & Clark, 2000). The module then becomes available for further recombination with other components compatible with its interface. Digital technology has impressed an acceleration on this process. "Five decades ago, the economy contained many separate and incompatible technical systems, managed independently by different firms. Today, through the evolution of digital technology, we are advancing towards a world comprising one large technical system with many interoperating and evolving parts" (Baldwin, 2015, p. 40). As discussed earlier, when these evolving parts are digital objects configured as modular components with a programmatic bitstring interface, they configure as digital resources. To the extent that their interfaces do not share assumptions or data with any specific design hierarchy (i.e., unbounded modular components within the "one large technical system") and they are amenable to address unplanned tasks (i.e., they are open), the resulting modules become available to organizations that can integrate them into novel recombination (i.e., new DSI). In summary, organizations can leverage digital resources that belong to multiple value paths (Henfridsson et al., 2018), thus increasing the variety and scope of combinatorial technology evolutions upon which to envision and deploy value creating digital strategic initiatives.

Servitized

The term servitization originally stems from the emphasis devoted to services by manufacturing firms seeking "to gain a competitive edge" (Vandermerwe & Rada, 1988, p. 319). More recently the service dominant logic (Vargo & Lusch, 2004, 2008) has shifted the value creation discourse toward "the processes of serving rather than on the output in the form of a product offering that is exchanged" (Lusch & Nambisan, 2015, p. 156). This shift is often fueled by the diffusion of digital technologies (Yoo, 2010).

Servitization spotlights the managerial and contractual enablers of combinatorial technology evolution. Research on digital platforms addresses the role of boundary resources in governing the interactions between the platform and its users (Eaton et al., 2015; Ghazawneh & Henfridsson, 2013). This research shows how "the software tools and regulations that serve as the interface for the arm's length relationship between the platform owner and the application developer" (Ghazawneh & Henfridsson, 2013, p. 174) play a critical role in enabling the co-creation of a service ecosystem, thus facilitating the democratization of innovation by large and heterogenous groups of actors (Von Hippel, 2005). Servitization is increasingly affecting digital information infrastructure elements, whether internal to organizations or shared. Consider the difference between THISCO, introduced in 1988, and Stripe. THISCO (now Dhisco) started as a technology start-up funded by sixteen of the world's largest hotel chains. They designed, implemented, and managed two-way interfaces between hotel central reservations systems (CRS) and the global distribution systems (GDS) that intermediate airfare sales (Davis, 2002). From a technical standpoint, both THISCO and Stripe rely on technological interfaces between heterogenous and independently owned computer systems. However, while THISCO negotiates each interface directly with the CRS and GDS owners, Stripe enables developers to recombine its payment system into their applications simply by inserting a few lines of integration code connecting to Stripe's API. All contractual elements of the relationship are coded into the digital resource interface. In our language, Stripe resources are *servitized* while THISCO's are not. The result is that relationship and governance become dynamic and agile, enabling firms that engage in combinatorial technology evolution to obtain the service on an as-needed basis and to pay for it based on consumption. The ability to encode the contract structure into bitstring represents a fundamental shift compared to the traditional intra- or interorganizational systems studied in IS research (Rai et al., 2006), such as THISCO, where both governance and technical agreements required lengthy negotiations and formal arrangements. In summary, organizations seeking to design and implement DSI can increasingly leverage servitized digital resources dynamically, rather than having to own the assets they need to envision and deploy value by creating digital strategic initiatives.

Digital Strategic Initiatives and Value Creation

We introduce two value creation pathways specific to DSI: (1) orchestration of digital resources, and (2) creation of novel digital resources. Orchestration is the purposeful assembly of elements and components into a designed artifact. The firm intentionally arranges digital resources, IT resources, and complementary organizational resources into a value proposition for its customers through an orchestration DSI. This approach emphasizes value creation through a pattern of interlocking activities (Rivkin, 2001), whereby the firm uses digital resources to establish value propositions previously unavailable or unfeasible.[13] Figure 2 shows a DSI orchestrator crafting a value proposition for its customers by assembling internal digital resources, external digital resources provided by DSI creators, and traditional IT resources and organizational capabilities.

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[13] The concept of DSI orchestration is neatly captured in an early Jeff Bezos quote: "Developers are alchemists and our job is to do everything we can to get them to do their alchemy" (Bezos as quoted in Stone 2013 p. 213). Amazon Web Services was therefore designed as a set of business computing "primitives" (i.e., modular components) that Amazon developers could reuse and recombine (i.e., orchestrate) across many diverse internal DSIs.

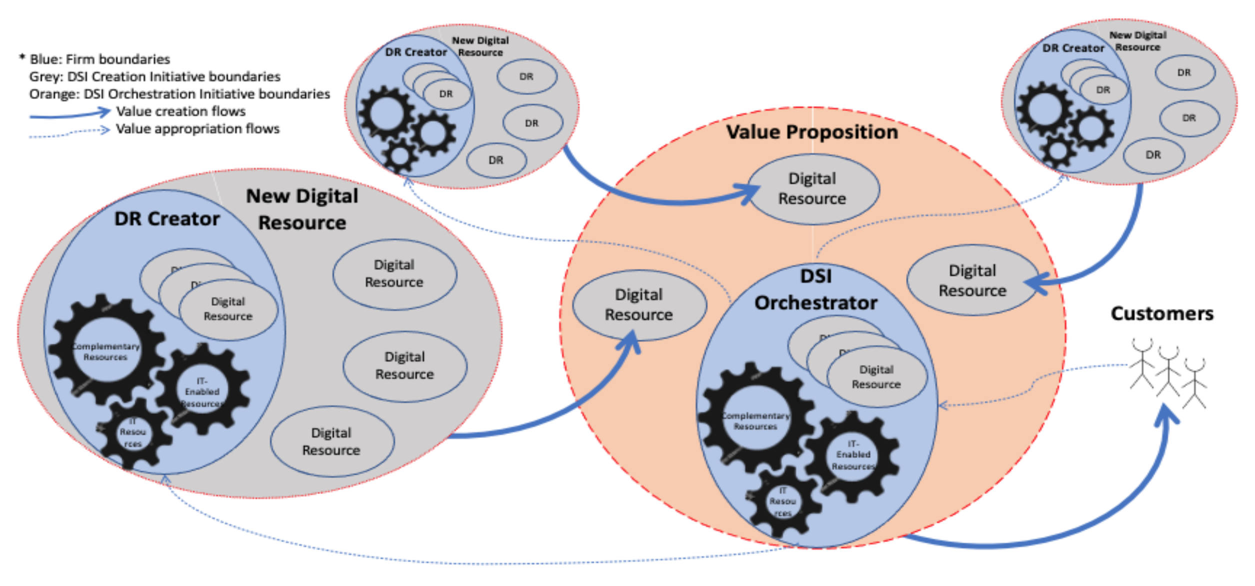

Figure 2. Digital Strategic Initiatives: Orchestration and Creation of Digital Resources

While also requiring the orchestration of resources, creation DSIs result in a specific value proposition: a new digital resource. The new digital resource may be used internally in the creator's own DSIs or be designed for consumption by external DSI orchestrators so that, once servitized, it enables the resource creator to appropriate a portion of the value it helps DSI orchestrators realize.

In the remainder of this section, we provide four case illustrations (Siggelkow, 2007): two for the orchestration DSI pathway (by a start-up and an incumbent) and two for the creation DSI pathway (a digital capability and a digital asset). The cases are not intended to be rigorous analyses of DSI archetypes or to provide in-depth treatment of the three environmental catalysts of DSI. Rather, they serve as "additional (but not sole) justification" for the research contribution (Siggelkow, 2007, p. 23).

Digital Resources Orchestration (Instacart)

Instacart[14] is a San Francisco-based start-up founded in 2012. The firm focuses on grocery delivery, enabling customers to select items from about 600 million listings across 20,000 locations of over 300 different national and regional retailers and have the order delivered to their door in under two hours. While delivery is not a new concept for grocers (Ives & Piccoli, 2002), grocery delivery at scale is extremely complex and the category is renowned for the story of Webvan, the largest bankruptcy of the dot-com era (Deighton & Kornfeld, 2015). Incorporated in 1996, Webvan closed its doors in June 2001 after spending over $1.2 billion (Wohlsen, 2014). When designing its IT-dependent strategic initiative in 1996, Webvan had no choice but to develop a highly integrated online ordering and delivery system because it launched the service in an environmental context characterized by underdeveloped infrastructure and a lack of useful digital resources. Webvan had to hire drivers, build warehouses, purchase trucks, write custom software for order collection and fulfillment, install servers, and run its IT infrastructure in dedicated data centers. Those resources simply did not exist in a combinatorial and servitized form that was conducive to DSI orchestration.

Conversely, Instacart is predicated on the existence of a digital information infrastructure that includes a full stack of networking hardware and communication protocols enabling real-time data exchange and mobile devices in the hands of both customers and freelance shoppers (i.e., an environment that is infrastructural, combinatorial and servitized). Those assumptions impact both the design architecture of Instacart

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[14] Instacart was selected because it offers a clear example of an orchestration digital strategic initiative: the Instacart service. Moreover, the company engages in thought leadership by publishing blogs and resources that explain its technical and strategic decisions. Thus, despite not having access to internal Instacart data, we downloaded and analyzed all posts in Instacart's general (https://news.instacart.com/) and technical (https://tech.instacart.com/) blogs (334 articles), interviews with, and keynotes by Instacart executives for a total of approximately 341 pages (170,774 words) of transcripts.

systems as well as its underlying business model. Thus, the structural differences between Instacart and Webvan are a function of the different environmental contexts in which the two firms were created. But they also reflect conscious strategic decision-making on the part of Instacart management, which recognizes and embraces its position as a DSI orchestrator: "We tried to build the things that we are uniquely suited to build … we are uniquely suited to build a great front-end e-commerce experience, and a great enterprise experience for grocers, we are uniquely able to fulfill, we are uniquely able to onboard shoppers and give them a great experience. We are not as well suited as other people [like Stripe] to have the payment infrastructure for the entire thing" (Gupta, 2019).

Unlike Webvan, which had to build, secure, and maintain its own IT resources (e.g., data centers), Instacart relies on digital resources such as Amazon Web Services (AWS) RDS and EC2, for relational database storage and virtualized computing resources, respectively. Whereas Webvan had to purchase a fleet of trucks, hire drivers, and employ grocery pickers, Instacart orchestrates the services of freelance shoppers who work self-scheduled flexible hours, own mobile computing devices enabling their interactions with the company and customers, and receive variable pay depending on the number of deliveries they execute (Deighton & Kornfeld, 2015). On the payment side, Instacart uses Stripe and never considered insourcing payment capabilities (Gupta, 2019). On the messaging side, Instacart uses Twilio and never considered insourcing a messaging infrastructure or messaging capabilities: "I don't think we could have started Instacart without Twilio. When we started out, dispatching orders to shoppers was a key problem, and Twilio was an enabling technology for us" (Mullen, 2020). Real-time communication is critical not only to dispatch shoppers once orders are received. It also ensures that shoppers can communicate grocery substitutions to customers while at the store and receive approval, thus ensuring greater customer satisfaction when originally ordered items are out of stock: "While your shopper is preparing for your order, be ready to respond to questions she or he may have about replacement options by using our in-app chat functionality" (Instacart, 2020). Note that an orchestration DSI does not rely exclusively on digital resources because, as in the case of IT-dependent strategic initiatives, the firm typically coordinates and deploys IT and complementary resources as well (Table 4).

While a complex DSI requires IT resources, IT-enabled resources, and complementary organizational resources, the Instacart illustrative case demonstrates the prominent role that digital resources play in an orchestration DSI. As recognized by Instacart's leadership, digital assets such as maps and digital capabilities such as payment processing, fraud detection, and messaging are core to Instacart's value proposition. Those resources were not available when Webvan tried to introduce online grocery ordering and delivery, and without them, Instacart's DSI would have not been technically or financially feasible.

Digital Resources Orchestration (BBVA)

Digital resource orchestration strategies are not the exclusive province of high-profile Silicon Valley start-ups like Instacart. Banco Bilbo Vizcaya Argentaria, S.A. (BBVA) is a global Spanish financial group founded in 1857.[15] Today, the bank is one of the world's largest financial institutions, offering diversified financial services to more than 70 million corporate and private customers in more than 30 countries worldwide.

The banking industry was a pioneer in the strategic use of IT resources in the 1970s and 80s, introducing many systems that still make up the backbone of the financial industry (e.g., automated clearing house). Those legacy systems were architected as monoliths, highly integrated applications relying on custom software and dedicated IT infrastructure. As in the case of Webvan, these choices were not due to a lack of foresight, but rather to the absence of a combinatorial servitized digital information infrastructure. Banks historically had to provision mainframes, configure internal organizational networks, and write custom and integrated COBOL software to enable their operations.

Under pressure from FinTech start-ups, and constrained by its legacy infrastructure, BBVA embarked on a digital transformation grounded in two imperatives: adopting a customer-centric approach and rapidly introducing new products and services (Alfaro et al., 2019). The most visible element of BBVA's transformation is its Mobile Banking App, released in 2015 as a result of a DSI orchestration effort leveraging internal and external digital resources:

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[15] BBVA was selected because it offers a prototypical example of how major incumbents can carry out DSI of both the creation and orchestration type. It shows how internal resources that are rearchitected as digital resources for internal use can then be exposed for external consumption. Finally, the company also provides an example of how incumbents can implement sophisticated DSIs of the orchestration type by leveraging internal and external digital resources. We had direct access to interview managers in the digital banking, data strategy and engineering areas. We combined data from interviews and follow-up emails with public source information explaining the company's technical and strategic decisions. We analyzed the transcripts from our interviews, posts from BBVA's blogs, and public interviews and keynotes by BBVA's top management for a total of approximately 54 pages (27,064 words) of transcripts.

Table 4. Examples of Digital and IT Resources Orchestrated by Instacart

Resource	Type	Description	Explanation
Grocery catalog	IT asset	Digital representations of 600 million grocery items (price, name, image), from over 20,000 supermarkets. Data is compiled from grocers and is owned by Instacart.	The data is fed to Instacart once a day by the grocers who transfer a flat file, typically a comma-separated values (CSV) file. The CSV is neither modular nor encapsulated in a programmatic interface.
Item availability predictive engine	IT asset	Single-item availability is predicted every 60 minutes using a machine learning model with about 800 features drawn from historical availability, store location, item purchase history, and real-time shopper inputs. Instacart uses this predictive application to adjust items displayed to customers, preemptively asking for substitutions of items likely to run out.	The predictive engine uses a custom pipeline for both model training and model deployment. Once trained, the model is made available from an AWS S3 bucket so that items can be scored and then loaded into the operational database for the relevant use cases (e.g., items search and availability in each store's order screen).
Maps	Digital asset	Instacart incorporates maps exposed by Google or Apple in its shopper- and customer-facing apps. The choice of mapping applications to use inside Instacart is left to user discretion.	Digital maps from large providers (e.g., Google, Apple) are designed as modules. Thus, Instacart integrates them into its apps through a software interface.
Cloud-first development	IT capability	Item availability predictive models had to be custom developed using the cloud infrastructure. As described by the firm: "making our 500,000,000 item listings across 20,000 locations easily browsable *is really hard to do well*. … To do this, we rely on Elasticsearch, and a seven-year backlog of catalog and purchase data." (Instacart, 2019)	Technical skills are a classic example of IT capability. Because of its native cloud development, Instacart introduced a number of organizational capabilities focused on cloud-first development. While novel in their content, conceptually they fit the traditional definition of IT capabilities.
Payment processing	Digital capability	Instacart collects money from the customer, pays the grocery stores, and, upon demand, the shopper. Instacart handles adjustments, refunds or discounts using payment processing capabilities exposed by Stripe.	The capacity for money transfer is embedded in Stripe's payment processing algorithms, and the contractual relationships and technology interfaces it has with financial institutions.
Fraud prevention	Digital capability	Before fulfilling an order Instacart ensures that the credit card being used is legitimate. To do so it interfaces with Sift a firm that exposes a fraud prevention digital capability.	The capacity for fraud prevention is embedded in Sift's machine learning algorithms and exposed through an API.
Grocery store layouts	IT or digital asset	In an effort to speed up deliveries, Instacart provides shoppers with optimized routes through the store. These routes are based on the digital representation of store layouts.	Some stores expose layouts as a digital asset, having modularized and encapsulated them behind a programmatic interface for use in other applications (such as the grocery store's own app). For most stores, however, Instacart builds the map internally based on data transferred from stores (IT asset).
Real-time messaging	Digital capability	Real-time communication is essential to the delivery of Instacart's value proposition, helping the firm optimize shopper dispatch and maximizing customer satisfaction by enabling real-time communication with shoppers (e.g., verifying how ripe bananas should be by sending a picture, choosing the best substitute for a missing item).	The capacity for real-time messaging is embedded in Twilio's messaging system. Instacart integrates such digital capability via a programmatic interface that manages both the technical specification and the contract structure governing its use.

> *BBVA bet for digital transformation took place almost a decade ago. In many places of our footprint in Latin America or Turkey, our customers didn't have desktop computers at home and our branches network was not as dense as in Europe, but they had smartphones. Besides, in other regions such as Spain or the USA they were demanding 24/7 availability for their informational and operational bank services, so the big bet was to deploy a useful, a nice easy to use experience as a mobile application, with the ability to carry out almost every interaction that customers could make in the brick and mortar branch*. (J. Murillo, personal communication, 2020)[16]

Echoing the experience of AWS, BBVA executives realized the need to restructure internal services with the objective of facilitating the rapid development of the mobile app's many functionalities by a large number of developers working in parallel: "To allow orchestration of those internal resources you need to abstract the developer from the complexity of your system. They want and need to completely ignore what is happening under those open APIs." (Serrano, 2019).

The key digital resource enabling the design and implementation of the app is what BBVA calls the "Accounts API." The Accounts API is a digital asset that exposes customers' account and transactional data (e.g., debits and credits, their value, their description, and their status) via a programmatic interface (i.e., RESTful API). Thus, the app designers need not worry whether the modular component is "executed on-premise or in-cloud, or whether the databases technology storing customers' data are IMB Db2, Oracle, MongoDB or other databases" (R. Navarrete, personal communication, 2021). Before the creation of the Accounts API, the mobile app designers had to establish ad hoc connections with each legacy system containing different aspects of the customer banking experience (e.g., name, address, number of accounts, transactions, loans, and investments). This required integration of the different systems of records by resolving data and technical conflicts emerging from the legacy systems' batch processes. Aside from being slower, these legacy system processes were less secure and made transaction monitoring difficult.

Once rearchitected as a digital asset, the app designers could orchestrate the Accounts API by simply following the specifications of its programmatic software interface that regulates both the technical (e.g., REST endpoints) and governance (e.g., GDPR compliance) elements. As our theorizing suggests, once configured as a digital asset, the Accounts API module was available to multiple DSIs that required access to customers' account data. BBVA expanded its use to include the web and smartwatch apps, smart assistants (e.g., WhatsApp, Telegram, Google Assistant, Alexa), and internal applications used by associates at BBVA branches (R. Navarrete, personal communication, 2021).

As in the Amazon AWS case, the creation of internal digital resources spurred BBVA to carry out a DSI creation strategy. Enacted in 2016, the European Commission's Payment Service Providers Directive (PSD2) requires financial institutions to securely expose information from customers' payment/checking accounts to third-party providers (TPPs) upon customer request. The spirit of the directive was to foster innovation and competition in the financial sector by creating open, secure, and standard interfaces to individual and business bank accounts. Following the directive, in 2017, BBVA released the "account information service," exposing their internal Accounts API digital asset to outside organizations. By leveraging the service in their DSI, any TPP can gain programmatic access to the customers' account information (e.g., transactions, account balance), the same digital data asset previously exposed internally by BBVA and used in its Mobile App initiative. TPPs need only to follow the Accounts API interface specifications that, by complying with the PSD2 payment directive, enforce both technical elements (e.g., API call syntax, rate caps, throttling rules) and governance rules (e.g., accessible data elements, reasonable date range of historical transactions).

The PSD2 directive is predicated on the existence of an environment that is infrastructural, combinatorial, and servitized. Its enactment spurred a plethora of digital resource creation efforts. As of 2020, virtually all major European financial institutions had exposed their customers' account information and payment capabilities as a digital resource. By identifying the potential value afforded by leveraging digital resources from other banks, BBVA carried out another orchestration DSI in April 2021 when the Spanish bank announced:

> *BBVA is launching a new project, which represents another step in the bank's commitment to leading bank digitization in Spain. This development will allow those users who are not clients of the bank in Spain to carry out some operations, such as initiating*

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[16] As with any orchestration DSI the BBVA Mobile Banking App initiative does not rely exclusively on digital resources. Rather it coordinates several IT and complementary resources as well. For example, BBVA uses proprietary ML algorithms that can produce sensible investing suggestions underpinning the app's virtual advisor. BBVA also leverages external digital resources, such as the S3 Authentication by Nok Nok, which provide a secure online user authentication process by enforcing the FIDO standard. Having discussed the variety of resources in the Instacart example, for the sake of brevity, we focus this illustrative case only on the principal digital resources in the BBVA Mobile Banking App.

> *payments, with their mobile application. In this way, they will be able to add accounts from other financial entities, request transfers from said accounts and use digital tools such as BBVA Valora in an unlimited way.* (BBVA, 2021)

Many of those other financial entities are financial institutions that have reconfigured their internal services as digital resources and exposed them to outside organizations.

Digital Capability Creation (Stripe)

Stripe[17] is predicated on the existence of a digital infrastructure that includes multiregional card networks and a full stack of networking hardware and communication protocols enabling real-time data exchange among consumer devices, merchant web applications, and Stripe software hosted by AWS. Stripe's business was designed from its inception with the assumption of being a service provider that exposes digital payment capabilities:

> *We believe that payments [are] a problem rooted in code, not finance. We obsessively seek out elegant, composable abstractions that enable robust, scalable, flexible integrations ... Stripe is a technology company that builds economic infrastructure for the Internet. Businesses of every size—from new start-ups to public companies—use our software to accept payments and manage their businesses online. Because we eliminate needless complexity and extraneous details, you can get up and running with Stripe in just a couple of minutes.* (Stripe, 2020)

Stripe's digital payment capability encapsulates an object of substantial value for any organization seeking to complete online financial transactions. Consider the specific case of a multisided marketplace like Instacart. Instacart collects money from its customers and must be able to transfer the full amount charged to the supermarket's accounts as soon as the checkout transaction occurs. Contextually, Instacart needs to charge the supermarket's account to collect the agreed-upon contractual fees and credit Instacart's shoppers for their portion of the revenue. The complexity absorbed by Stripe on behalf of Instacart is apparent when customers request a refund for one or more of the items delivered. Refunds in this scenario are complicated, as they include four parties: the customer, Instacart, the grocery store, and the Instacart shopper. Before issuing a reimbursement, Instacart needs to return to the supermarket the fees they debited in the original transaction. Only then can Instacart transfer the original amount from the supermarket's account to the customer.

From a technical standpoint, accepting credit card payments requires the implementation of ad hoc infrastructure, back-office applications, and databases to connect and integrate a checkout and payment page for customers, the merchant application, and a card network system (e.g., Visa, Mastercard). Once card information is captured and encrypted in their back-office application, merchants need to send an authorization request to a card network system following the international standard specific to financial transactions (i.e., ISO 8583). Each card network requires detailed technical specifications that necessitate ad hoc integrations. In addition, the same card network can have several regional connections and thousands of different credit card issuers, each requiring slightly different specifications. In addition to the technical complexity, the merchant would also need to develop detailed knowledge about the financial regulations governing the type and geographic location of the parties involved in the transaction (e.g., SCA regulation, PCI DSS).

Stripe abstracts this technical and financial complexity into a digital capability, then exposes it for a fee to any organization ready to integrate the payment capability via Stripe's programmatic bitstring interface. Because Stripe Payment is modular, customers such as Instacart need no technical infrastructure and no knowledge of any financial regulations or the ISO 8583 standard to transact online. They need no direct relationship with credit card issuers or banks, other than the one they use to receive deposits. Abstraction of technical and regulatory complexity and a modular design guarantee that any interactions (e.g., refunds) between the merchant and Stripe occur systematically through the digital capability's programmatic interface:

> *What Stripe does is take the complexity and abstract it away from people. If you talk to anyone who's ever had to do [online payments], [you would know] you're getting into having in-house teams of payments experts for any company operating at any kind of scale internally. Which is not the way at all it should be ... Our idea is to make that available as a platform to companies, so then they can focus on what's actually a good use of their time, which is competing on product*. (Collison, 2017b)

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[17] Stripe was selected because its first and most important product is a digital capability: Stripe Payments. Moreover, the company constantly engages in regularly publishing blogs, product documentation, interviews, and presentations that explain the technical product specifications and strategic decisions implemented by the firm. Despite not having direct access to Stripe's management, we downloaded and analyzed all posts in Stripes blogs (257 articles), Stripe Payments documentation, in-depth interviews of its co-founders, and conference presentations (10 video transcripts), for a total of approximately 358 pages (178,884 words) of transcripts.

Because Stripe is structured as a digital capability, it has a programmatic interface. When integrating Stripe Payment, a merchant simply incorporates a prebuilt user interface component, a payment form, to collect and validate the card number, ZIP code, expiration date, and any other information required by the transaction. The same component securely sends the payment information to Stripe's servers over an HTTPS connection. When submitting the charge request, merchants comply with the interface specifications, which require the definition of an amount to charge and the currency of the transaction. Because the complexity of the transaction is hidden behind the digital interface, a complex functionality like the one required by the split payments and refund transactions performed by Instacart is handled very elegantly with a single optional parameter (aplication_fee_amount) in the interface of the payment module.

In addition to technical requirements, Stripe also embeds governance rules into the Stripe Payments programmatic interface. For example, the form that collects transaction data can dynamically adapt to meet business and legal requirements. Business factors that may prompt changes include the expected risk level of the transaction (e.g., a bank's overall fraud rate), the merchant's headquarters, customer location, and the like. Legal obligations might also require additional information, such as two-factor authentication, to meet country-specific requirements.

More generally, via the interface, Stripe monitors and enforces its agreement with the merchants. Consider Stripe's fraud-blocking capability. Before processing a charge, Stripe performs a risk assessment of the transaction in the form of a risk score. Depending on the risk tolerance set by the merchant, Stripe blocks any charge that exceeds the specified threshold. The risk tolerance can be modified by the merchant at any time without coordination with Stripe. Similarly, Stripe imposes a limit on the concurrent number of payments a merchant can process. As a consequence, when a merchant exceeds this limit, Stripe automatically halts new requests initiated by the merchant: "[Stripe] wants to focus on developers and built the product as an infrastructure platform where the medium in which [merchants] are actually working is the code and a set of APIs" (Collison, 2017b).

The Stripe illustrative case demonstrates Stripe Payments' structure as a digital capability with a modular design and a programmatic interface. The uniqueness of this structure is clear when the digital payment capability is juxtaposed to a traditional IT-enabled payment capability resulting from the integration of IT assets (i.e., Ingenico Move/5000 POS) with a merchant's own organizational payment capability (see Table 5).

Digital Asset Creation (AWS EC2)

Amazon Web Services (AWS)[18] launched as a subsidiary of Amazon, Inc. in 2006. AWS is a cloud platform offering over 175 services hosted in numerous data centers globally. Services include computing, storage, database, application deployment/management, and many other servitized computing resources. AWS is predicated on a fast and reliable information infrastructure that includes both networking hardware (e.g., ISP, DNS) and communication protocols (e.g., TCP/IP).

AWS's most popular solution remains its foundational computing service, Amazon Elastic Compute Cloud (EC2). EC2 affords clients the provisioning of virtual instances they can leverage to run software applications or any other computing workload. From its inception, EC2 was designed to expose digital computing assets: "[Amazon] should be creating primitives—the building blocks of computing—and then getting out of the way. In other words, [Amazon] needs to break its infrastructure down into the smallest, simplest atomic components and allow developers to freely access them with as much flexibility as possible" (Stone, 2013, p. 213).

The AWS digital computing asset encapsulates an object of substantial value for organizations: a scalable, secure, reliable, and flexible computing primitive. While originally preferred by start-ups, the so-called public cloud is now a reliable option for organizations of any size. From a technical standpoint, provisioning computing resources requires the coordination of intricate activities, ranging from hardware purchase to disk imaging, software configuration, and networking of new hardware with the firm's existing infrastructure. Once the computing resources are made available within the organization, they require continuous monitoring to preserve performance and security standards. As a modular digital asset, EC2 abstracts and hides the substantial complexity inherent in traditional IT computing assets.

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[18] EC2 was selected because it is among the first and most important products offered by AWS. Moreover, there is extensive and detailed information about AWS history (Stone, 2013) and the architecture, governance rules, and technical product specifications of EC2. Despite not having direct access to AWS, we downloaded and analyzed EC2 user documentation (1,278 pages), and conference presentations (6 video transcripts) for a total of approximately 119 pages (59,389 words) of transcripts.

Table 5. Stripe's Digital Capability versus a Traditional IT-Enabled Payment Capability

	Stripe Payment	**Ingenico Move/5000 POS**
Object of value	Yes: The complete payment capability is made available by Stripe.	Yes: Ingenico provides secure and reliable credit and debit card processing terminals. Using these physical terminals, merchants verify customers' solvability and process credit and debit card transactions. Ingenico provides IT assets to merchants, only requiring small configuration and training. Yet, the merchants must integrate those IT assets with their organizational resources (e.g., payment experts) thus structuring an internal IT-enabled payment resource.
Modular	Yes: All aspects of the transaction are abstracted and hidden behind the interface.	No: Ingenico requires ad hoc integrations between the payment module and the adopting organization. Merchants need to train employees about the correct use of the POS and rely on organizational processes to enforce governance. For example, consider the manual check that car rental employees need to perform to verify whether customers are using a credit, debit, or prepaid card. Similarly, small retailers manually enforce lower bounds for credit card transactions (e.g., minimum $10 charge). As an IT-enabled resource, the Ingenico-based payment system is not modular.
Programmatic interface	Yes: As described above, Stripe Payment requires no manual intervention, and all cases are handled via its programmatic digital interface.	No: Ingenico's interface is manual and requires knowledge of the inner workings of the merchant's payment terminal. All interactions with the payment module are operated through the manual interface of the proprietary Telium TETRA Operating System (OS). All transaction types can only be initiated from the "Transaction Menu," and the merchant is required to manually input and confirm the amount before the card can be accepted. Furthermore, other payment functionalities require manual intervention during the checkout process. For example, when customers pay with a credit card issued by a foreign bank, the merchant's employee is required to select the type of currency that needs to be used for the transaction.

The provisioning and maintenance of a global computing infrastructure are abstracted into an independent module (i.e., EC2) hidden from its customers, with interactions resolved in a preestablished manner at the module's interface. EC2 enables the use of cutting-edge computing infrastructure while at the same time avoiding redundant and ad hoc interactions: "What was even more disruptive was a credit card was all that was needed to provision [assets]. There was no required proposal for financial approval, there was no RFP, no vendor selection process, no vendor negotiation, and no data center space need be found. I could just sign up and start working" (Hamilton, 2016). This architecture differs from traditional IT infrastructure forcing organizations to provision and manage private data centers and to operate the needed hardware and software assets.

Being a digital asset, EC2 has a programmatic interface. As a result, both the technical specifications and the governance of the computing resources are implemented via preestablished and programmatic routines and exchange of data. There is no need for organizational coordination between the client and AWS. For example, Instacart can spin up a virtual server and provision computing power by simply issuing a command (i.e., programmatically). Instances are configured (e.g., RAM, network bandwidth, operating system) via additional arguments that are well documented in the EC2 manual. As all the complexity is hidden behind the programmatic interface, organizations can implement advanced solutions, such as autoscaling of resources, via structured commands exposed by the EC2 digital asset. These characteristics of EC2 were critical during the COVID-19 pandemic for AWS customers like Instacart: "Our number one mission throughout March [2020] was to scale out our infrastructure ahead of our trajectory of 20% day-over-day growth. This infrastructure is the foundation for our four-sided marketplace including our customer-facing app, shopper app, enterprise software, and advertising engines" (Schaaf, 2020). The increased computing capacity enabled Instacart to make critical adjustments to their product: "We doubled the rate at which we were running our item availability model, running it every 60 minutes to better understand availability fluctuations throughout the day" (Schaaf, 2020).

EC2's digital interface also embeds governance rules that regulate the interactions between AWS and its clients. Depending on the instance characteristics, different billing rules (e.g., by the hour or the second) or service level agreements (e.g., frequency of service interruption) are enforced. Furthermore, the users of the EC2 digital assets maintain control over cost, compliance, and security through the specification of programmatic workflows and rules. For example, budget restrictions can prevent some user groups within an organization from spinning up new instances or limiting the performance of their current instances.

Discussion

The four illustrative cases we discuss demonstrate the *structure* and *design* of digital strategic initiatives (DSI), highlighting the characteristics of orchestration DSIs and creation DSIs. The cases also demonstrate how digital resources, with their modular design, encapsulation of value, and programmatic interface, flourish in the increasingly infrastructural, combinatorial, and servitized context that empowers what Gartner calls the composable enterprise (Yefim et al., 2021). The multibillion-dollar valuation of the most successful digital resource creators is justified by the expectation that they can deliver modular components to a wide range of DSI orchestrators.

Firms' value creation and capture efforts are increasingly hinging on their ability to develop and commercialize useful digital resources (i.e., creation DSI) and/or on their ability to purposefully arrange digital resources with complementary assets and capabilities to craft DSI (i.e., orchestration DSI) that engender new value propositions (Lawson, 2021). As the Amazon and BBVA examples demonstrate, the two approaches are often related. Amazon recognized the need to build agility with internal digital resources, composable business primitives that would free business units to orchestrate new DSI faster and cheaper (Stone, 2013). The firm approached the creation of digital resources as a general solution to a class of problems that would manifest in the future.

The cases also clarify the structural differences between digital resources and traditional IT resources. Consider the way Instacart maintains its digital catalog. Grocery stores upload daily lists of available SKUs, typically structured as CSV flat files, to a storage service that Instacart uses for data ingestion. The catalog is the basis for item availability appearing on Instacart's website and app. The flat files are traditional IT assets. They are not modular, and Instacart engineers need to coordinate several decisions pertaining to their structure (e.g., data type, data dictionary) and transfer (e.g., location, timing) with the store's IT department. Even minor changes to the files' internal structure require coordination across the companies. Moreover, the datasets are not accessible by way of a programmatic interface. They need to be physically transferred, in their entirety, to the designated storage space, ingested by Instacart's transfer and load scripts, and integrated with existing data. This process is predicated on substantial coordination between Instacart and the grocery stores. Leveraging digital assets, such as BBVA Accounts API, entails a different process. First, because BBVA employed abstraction and information-hiding principles, third-party providers (TPPs) need no knowledge about the module's inner structure. Access to BBVA customer data is programmatic and fully managed through a digital interface upon customer approval.

An important insight demonstrated by the cases pertains to the recursive composition of digital resources. Research on digital resources and modularity, like work on traditional organizational capabilities (Winter, 2003), business processes (Ray et al., 2005), and systems in general (Simon, 1996), confronts the issue of recursion. Recursion is apparent in the case illustrations of BBVA and Amazon, which created digital resources to engage in DSI orchestration. It is also evident in the case of Stripe, which uses digital resources exposed by Amazon (e.g., AWS EC2 and S3) to deliver the Stripe Payment digital capability. Because of recursion, researchers should treat digital resources as atomic when further decomposition is immaterial (Leonardi, 2010). In other words, what comprises a digital resource in a specific situation depends on the firm's objectives for creating or orchestrating the resource. DSI orchestration requires the utilization of coherent, fully formed digital resources that are combined to provide a value proposition to customers, as in the case of the BBVA mobile app or the Instacart grocery delivery service. Digital resource creation requires the design and implementation of a modular cohesive whole that can be exposed for use in orchestrator DSIs (Figure 2). As in the case of Stripe Payment's reliance on AWS compute and storage primitives, digital resources are often recursively composed of digital resources.

Our illustrative cases highlight how it is an increasingly infrastructural, combinatorial, and servitized environment that fosters DSI orchestration and makes digital resource creation a viable pathway for value creation and appropriation. For example, having succeeded in the creation of specialized digital resources for internal reuse and recombination, Amazon explored the opportunity to commercialize them in 2003—a time when the three environmental catalysts were first emerging. BBVA followed a similar evolutionary path a decade later, at a time when the consolidation of the combinatorial, servitized digital information infrastructure emboldened the EU to issue a directive requiring banks to securely expose valuable information for reuse and recombination by third-party providers (TPPs). Such a directive would have been unfeasible in a context dominated by the need for integrated in-house software development. Lastly, the juxtaposition of the options available to Webvan and Instacart in the design of the same value proposition, convenient grocery shopping, and delivery, provides a powerful illustration of the role played by the environmental catalysts available to organizations designing and developing digital strategic initiatives.

Digital resources at the core of DSIs have unique characteristics that differentiate them from organizational and IT resources as traditionally defined. It is their unique structure that warrants naming them *digital* resources. The case illustrations show that digital resources encapsulate objects of value and become "building blocks in the creation and capture of value" (Henfridsson et al., 2018, p. 92). However, being building blocks (i.e., modular components) is not enough to warrant new terminology. Modularity has been a hallmark of many IT assets since the introduction of IBM System 360. Recent theorizing has also pointed to the novelty of resource liquefaction (Lusch & Nambisan, 2015), suggesting that digital resources can simultaneously be part of multiple value paths and are often product agnostic (Henfridsson et al., 2018). While all innovations result from the recombination of existing resources (Arthur, 2009), our work builds on previous contributions to show how it is modularity, coupled with encapsulation by a programmatic interface, that enables the possibility of *digital* recombination in multiple value paths.[19] It demonstrates that the objects of value encapsulated in digital resources are accessible to external DSI design hierarchies as nonmaterial *digital* objects. Because of their unique structure, they are *visible* and *usable* purely as bitstrings within the design architecture of the digital strategic initiatives that orchestrate them into novel value propositions, regardless of their actual internal architecture or materiality. Thus, an organizational capability or asset, configured as a digital resource, is abstracted and made available for orchestration as if it were an imported code library.[20] This is not the case for organizational and IT resources as traditionally defined, which require substantial integration effort to yield IT-enabled resources (Nevo & Wade, 2010).

We hope that the definitional precision advanced in this paper helps the IS discipline claim centrality with respect to Digital "x" phenomena while demonstrating the fallibility of unquestioningly replacing IT "x" with Digital "x." In line with recent calls for the label *digital* to capture "the idea that our surroundings, our economy, and the way we live our lives is digital in important ways" (Baskerville et al., 2019, p. 512), we show that digital resources are unique in important ways that matter for strategic initiative design and implementation. As software increasingly "programs the world" (Andreessen et al., 2016), it is IS scholars who, we believe, must provide the definitional and theoretical foundations to study Digital "x" phenomena.

Future Research

The ontological foundation set in this paper opens a wealth of promising avenues for future research to advance the digital strategy agenda (Henfridsson et al., 2018; Yoo et al., 2010). The work can be organized along three themes: DSI design and implementation, organizing for DSI, and DSI strategic outcomes (Table 6). The first addresses questions about DSI antecedents. For example, firms engaging in digital resource creation must identify the object of value their modular components will encapsulate and expose. They must ensure that the digital asset or capability they bring to market is a fully formed modular component and that it encodes both technical specifications and governance rules into a programmatic bitstring interface. Failing to do so would prevent the resource from being readily accessible to DSI orchestrators. A growing literature is looking at these challenges under the "API strategies" label (Davenport & Iyer, 2013; Iyer & Subramaniam, 2015) and recognizing the importance of APIs as "digital control points that set the terms for which data and services can be efficiently shared" (Evans & Basole, 2016, p. 26). APIs are a common approach to interface design (Wang & McLarty, 2021), but not the only one,[21] and we contend that focusing on digital resources will yield more precise and complete findings.

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[19] Strictly speaking, many modern digital resource creators like Stripe and Twilio expose *ported* digital resources (Piccoli et al., 2020). In modularity theory, porting enables the abstraction of a module outside of the design architecture of any specific system. Porting requires a translator module (Baldwin & Clark, 2000) that ensures "two-way invisibility" enabling any system that incorporates the translator module to interface with the digital resource. To broaden the market for their innovation, digital resource creators often offer translator modules in the form of client-side libraries that developers must import into their own design architecture to accommodate the digital resource. Stripe, for example, offers translator modules in the most widely used programming languages (i.e., Ruby, Python, PHP, Java, Node, .NET) and product architectures (e.g., iOS SDK, Android SDK). Within this view, product agnosticism (Yoo et al. 2010; Henfridsson et al. 2018) is a special case occurring when digital resources are ported with appropriate translator modules and adopt open nonproprietary interfaces (Baldwin and Clark 2000).

[20] DSI orchestrators today can provision EC2 digital computing assets by issuing a single command (e.g., "aws ec2 run-instances --instance-type {instance_type}"), access BBVA customer account digital data assets by making a POST request (e.g., "bbva.com/accounts/{account_id}/transactions") or leverage Stripe's digital payment capabilities by making a RESTful API call ("api.stripe.com/v1/charges -d amount=2000").

[21] A programmatic bitstring interface enables interaction between two software systems or components. While REST APIs are today the most common implementation of this concept, there are early examples like electronic data interchange (EDI), current alternatives like event-driven interfaces, and emerging approaches like the use of Ethereum smart contracts, that caution against conflating the terms API and programmatic bitstring interface.

Table 6. Broad Themes for Future Research

Theme	Focus	Sample issues to study
DSI design and implementation	How can a DSI be effectively designed and implemented?	• Which IT assets can morph into digital assets? Are there optimal modularization patterns for data assets and software assets? • Which organizational capabilities can evolve into digital capabilities? What are their technical and governance interface requirements? • What is the optimal design of programmatic bitstring interfaces? Is it possible to encode sufficient governance rules into a programmatic interface? What role do emerging technologies, such as smart contracts on blockchain, play as elements of the interface? Are there different obstacles for assets and capabilities? • What is the trade-off for DSI orchestrators in choosing between internal digital resource creation versus external digital resource use? Are there optimal patterns of “fit” between digital resources and DSI value paths?
DSI and the organization	How should firms organize to thrive in the infrastructural, combinatorial, and servitized competitive environment fostering DSI?	• What are the organizational IS capabilities needed to foster DSI creation and orchestration? What are the organizational prerequisites to resource liquefaction? • Can organizations evolve in their ability to leverage digital resources? If so, how will IT capabilities evolve to enable successful DSI design and development? Are there technical or cultural catalysts (e.g., cloud migration, platform governance, digital values training) to facilitate this transition? • How do DSI impact the coordination mechanisms within and between organizations? • What organizational structures enable DSI orchestration? Do these enablers differ for DSI orchestration and creation?
DSI strategic outcomes	How do DSIs enable value creation and appropriation in the infrastructural, combinatoria,l and servitized competitive environment?	• Can value be effectively appropriated from DSI in the short and long run? What is the potential for value creation and appropriation by DSI creators? • How can DSI creators and orchestrators best cooperate and compete in the provision of digital resources? How can DSI orchestrators retain control of their initiatives without ownership of external digital resources? • What is the role of DSI as enablers of digital transformation and digital innovation?

The second theme focuses on the organization as the level of analysis. The IS discipline has long studied organizational IT capabilities that are critical to firm performance. Established IT capabilities, such as technical and relationship skills (Bharadwaj, 2000), are likely still relevant, but others will obsolesce. For example, with the emergence of an infrastructural, combinatorial, and servitized competitive environment, the ability to manage internal IT infrastructures loses importance, while cloud-first system design and DevOps capabilities take center stage. For DSI orchestrators, recent case studies and modularity theory have suggested that companies can promote a fertile environment for DSIs by enforcing modular organizational structures (Hamel & Zanini, 2018; Sanchez & Mahoney, 1996). We currently have limited knowledge about the evolution of traditional IT capabilities and which new IT capabilities will foster leadership through DSI and new digital resources.

The third theme focuses on DSI strategic outcomes, with specific attention to questions of value creation and appropriation. The IS literature holds that when IT resources are external and widely available to all competitors, they are easily imitable (Nevo & Wade, 2010). Thus, DSI based on widely accessible digital resources could contribute to hypercompetition and limit DSI orchestrators’ ability to capture value from their initiatives. At the same time, because of their modular nature, digital resources can facilitate search processes for identifying superior product performance and increase the speed of experimentation, thus enabling unprecedented value creation (Pil & Cohen, 2006). Moreover, unlike traditional IT resources, digital resources are often not fully owned by the designer of the DSI that employs them. Software programs or data repositories at the core of traditional IT-dependent strategic initiatives were acquired, licensed, and, thus, controlled by the firm implementing the initiative. Conversely, digital resources are recombined from outside the design hierarchy of the DSI and are often operated as "live" components by the resource creator. It is unclear how DSI orchestrators can best manage these live digital resources. The recent outages ensuing from a server-side update of Facebook's iOS SDK exposed the vulnerability of entire services structured as DSI orchestrations (e.g., Spotify, Venmo, Doordash). Aside from technical difficulties, the digital resource owner may "abruptly change pricing terms or even turn off an API that has become critical input into services that others have created" (Evans & Basole, 2016, p. 28). In one stark example, to prevent the exploitation of its customers' data, Twitter abruptly restricted the Twitter API in 2012—effectively crippling thousands of DSIs orchestrators that depended on Twitter's digital data assets. Future research should investigate the nature of lock-in and design dependencies that limit the flexibility and value capture potential of DSI orchestrators. It should also explore how digital resources creators can protect their innovations from imitation, particularly considering the recent Google LLC v. Oracle America, Inc. U.S. Supreme Court ruling stating that API specifications are not copyrightable.

Many digital resources encapsulate nonmaterial objects of value (e.g., maps, accounts data). Others are modularized IT-enabled resources accessible through a programmatic interface. Thus, digital resources are the result of yet another abstraction away from hardware (Faulkner & Runde, 2019) where the encapsulation of the object of value is increasingly removed from the physical bearer of the digital object. It would be intriguing to ask at what point the physical bearers underlying hybrid objects become irrelevant and we begin to practically consider encapsulated physical objects as digital. What conditions need to be in place for organizational resources to fully liquefy and take on the structure of digital resources? We explore this second question in depth here as an exemplar to frame future research that can leverage our theorizing.

Rearchitecting Organizational Capabilities into Digital Capabilities

By responding to recent criticisms of the nature of IT capabilities (Faulkner & Runde, 2019), our definition of digital capabilities broadens the scope of information systems research to a wide range of organizational capabilities. There are early case studies of firms reorganizing their operations around digital capabilities (Hamel & Zanini, 2018), and IT advisory firms talk of packaged business capabilities (PBC) as "software components that represent a well-defined business capability, functionally recognizable as such by a business user" (Yefim et al., 2021, p. 3). Yet, there is no academic research rigorously answering the question: *Which organizational capabilities can become digital capabilities* through complete abstraction, partial transformation, or substitution?

Theoretical Foundations of Organizational Capabilities Research

Organizational capabilities are an organization's latent "capacity to undertake activities" (Helfat & Raubitschek, 2018, p. 1393). The microfoundation of organizational capabilities are routines, the "repetitive, recognizable patterns of interdependent actions, carried out by multiple actors" in the organization (Feldman & Pentland, 2003, p. 95) through sociomaterial ensembles of actants with tools, templates, written procedures, and digital technologies (Leonardi, 2011). An organizational capability is a high-level routine (or collection of routines) that generates an observable repeatable pattern of actions in the use of assets, thus enabling a firm to perform an activity at a "minimum level of functionality that permits repeated, reliable performance" (Helfat & Peteraf, 2003, p. 999).

Capabilities are categorized functionally (e.g., IT capabilities) as well as hierarchically with respect to the codifiability of the knowledge needed to perform them (Collis, 1994; Wang & Ahmed, 2007; Winter, 2003). Routines, known as zero-level capabilities, are the heart of organizational capabilities. Once the firm demonstrates the ability to deploy a cohesive collection of routines to perform basic functional activities, such as distribution logistics, a first-order organizational capability is configured (Collis, 1994; Salvato & Rerup, 2011; Schreyögg & Kliesch-Eberl, 2007). At the highest level in the hierarchy are dynamic capabilities, defined as higher-level learned and stable patterns of routines or collections of routines that generate and modify lower-level operating capabilities (Zollo & Winter, 2002).

Theoretical Extension: From Organizational to Digital Capabilities

Organizational capabilities will vary widely in their rearchitecting potential to be configured as digital capabilities. The latent capacity to undertake a specific activity that results in a clearly recognizable business outcome (e.g., collect payment for services rendered) is the object of value. As we theorized, digital capabilities encapsulate such an object of value in an independent module and expose it to DSI designers via a programmatic interface. Thus, digital capabilities, particularly those intended for widespread commercial adoption (i.e., creation DSI), are not a priori designed for a specific design hierarchy. They leverage the programmatic nature of their interface and the availability of digital boundary objects (e.g., SDK, programming frameworks) to adopt standard interfaces that make them amenable to recombination into multiple innovations (Henfridsson et al., 2018). Thus, based on our ontological representation of a digital resource to configure as digital, valuable organizational capabilities must be modularized and made accessible by way of a programmatic interface.

Potential for Modularization: Propositions

As with any modular component, digital resources enforce information hiding through abstraction. Thus, its internal complexity (i.e., the design parameters that determine its form and function) is not visible to the other modules with which it is combined as part of a digital strategic initiative. We theorize that routinization and interdependence are relevant to modularization.

Routinization refers to the degree to which the capability relies on repetitive recognizable patterns of actions (Feldman & Pentland, 2003), leading to a clearly recognizable outcome (Helfat & Martin, 2015). The more routinized the pattern of activities, the less unpredictable and ad hoc interactions are. Routinized capabilities are captured by a set of clearly defined tasks, with predictable precedence relationships and clear ownership assignments. Under these circumstances, it is easier to modularize the resource because the distinct patterns in the sequence of activities displayed by routinized capabilities create "natural encapsulation boundaries" (Langlois, 2002, p. 25).

Proposition 1: *The more routinized organizational capabilities are, the more amenable they are to configure as digital capabilities.*

Interdependence refers to the degree to which the output of one action serves as the input to a related downstream activity (Thompson, 1967). Even small changes to any activity require coordination with upstream/downstream activities in highly interdependent systems (Baldwin & Clark, 2000). A precondition to modularization is the identification of all dependencies between modules, the so-called "bounding of the problem" (Baldwin & Clark, 2000, p. 28). Failure to specify precisely and exhaustively the parameters needed to fully modularize components engenders unexpected dependencies during system integration that negate the advantages of modular design (Ethiraj & Levinthal, 2004). It follows that the more insulated the capability is from other organizational assets or capabilities, the easier it is to identify potential points of interactions, making the ex ante specification of how they will interact possible.

Proposition 2: *The more interdependent organizational capabilities are, the less amenable they are to configure as digital capabilities.*

Potential for Access via Programmatic Interface: Propositions

Encapsulation of a digital capability occurs when its capacity to undertake activities is actionable via its programmatic interface, requiring no manual coordination with other modules. Thus, the repeatable pattern of actions that define the capability being modularized rely exclusively on the information received through its programmatic interface. It is through these parameters that the digital capability's latent "capacity to undertake activities [is] called into use" (Helfat & Raubitschek, 2018, p. 1393). Because of the nature of the interface, these parameters and inputs must be collectively exhaustive with respect to the capability's expected minimum level of functionality (Helfat & Martin, 2015). Therefore, if the necessary input/output requirements to interact with the capability cannot be specified, regardless of the capability's degree of independence, the capability cannot configure as digital. On average, we expect a negative relationship between the number of interface parameters required to successfully enact an organizational capability and its potential to configure as digital.

Proposition 3: *The greater the number of collectively exhaustive interface parameters required by organizational capabilities, the less amenable they are to configure as digital capabilities.*

A digital resource requires access via a programmatic bitstring. Thus, interface parameters must be expressed as software. Yet the interface parameters of different organizational capabilities may not be readily digitized. For example, while restaurants can programmatically request a driver to fulfill a delivery through the Stuart API, most have employees physically handing the food order to the rider. Industry pioneers are fully digitizing the interface by installing food lockers that can be electronically opened by riders, making the interface with the delivery module entirely programmatic. Note that whether the internal structure of the capability is purely information defined (e.g., payment, fraud detection) or its object of value is an IT-enabled resource (e.g., delivery fulfillment by Stuart's white label riders) is irrelevant. A capability configures as digital when it is *visible* and *usable* as software by DSI designers. Stripe, for example, has always enabled customers to incorporate its payment capability via the Stripe Charges API. But early iterations required the founders to manually "fill out the paperwork and submit it to [a payment processor], to 'instantly' set up your Stripe account" (Greylock, 2015). Because the internal structure of the module was abstracted away from DSI designers, “the salient point was [that Stripe customers] didn’t have to do it, … and [the founders] were fine doing it for them” (Greylock, 2015). What matters is the degree to which interface parameters and inputs can be expressed digitally, thus without any requirement of interaction between people or between people and objects. What parameters and inputs can be expressed digitally changes over time with the evolution of digital technology (Overby, 2008), and DSI designers will at times be able to bypass nondigitizable parameters—as in the case of restaurants using smart lockers for order pickup by riders or customers. However, if at any point in time the necessary number of digital input/output parameters required to deliver the minimum level of functionality cannot be provided by way of a programmatic interface, the capability does not configure as digital—regardless of its degree of modularity. Thus, the greater the efforts required to express an organizational capability’s interface parameters digitally, the lower the chances of configuring it as digital.

Proposition 4: *The greater the obstacles to parameter digitization of organizational capabilities, the less amenable they are to configure as digital capabilities.*

Conclusion

We hope that the richness and diversity of the research agenda that can be built on our ontological foundation will place the information systems discipline at the center of digital strategy theorizing. Replacing the traditional IT “x” concepts presents an opportunity to create improved conceptual clarity that considers the distinctive characteristics of novel digital phenomena. To that effort, we contribute a precise definition of key constructs: digital strategic initiatives and digital resources. While echoing recent research spotlighting the central role that digital resources play in digital innovation, we posit that the defining characteristics of digital resources are their *modular design*, *encapsulation of value*, and *programmatic interface*. We argue that DSI design and development thrive in an environmental context that is *infrastructural*, *combinatorial*, and *servitized*.

Ontological precision and sound theoretical grounding are critical elements of basic science. They are even more important in the context of digital strategy because the emergence of Digital “x” labels runs the risk of diluting the core of the information systems literature. With the widespread digital experiments being undertaken by companies as well as a rich landscape of DSI successes and failures, the world offers a living laboratory for studying Digital “x” phenomena as unique and distinct from well-established IT “x” phenomena.

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