Going Digital First as an Incumbent: Reaching Outwards and Anchoring Inwards to Safeguard the Incumbent Physical Core

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Abstract

Incumbent firms typically face significant risk of losing the relevance of their physical core when facing industry disruption driven by digital technologies. Existing literature emphasizes a digital first approach, whereby firm offerings are fundamentally redeveloped from a digital point of view, from the point of conception. While this prescription can help accelerate innovation, it does not tell us how incumbents might safeguard the relevance of their traditional physical core resources when going digital first. This is important, since major discontinuities in strategic repositioning, while often celebrated in digital innovation and transformation literature, create significant risks to firm survival. To this end, we conduct a grounded analysis of a European automotive firm's innovation journey over an eight-year period. We contribute to the digital innovation and transformation literature by developing a process model explaining how a digital first approach can be employed in a way that also safeguards the physical core.

Keywords: Digital first, digital innovation, digital transformation, incumbent firms, phygital

1. Introduction

"We used to have an invincible competitive advantage in our drivetrain for decades—our drivetrain [i.e., engine and transmission] is the best one in the industry. But due to electrification and autonomy, that whole differentiation advantage will completely fall away in [a few] years. Anyone can build an electric engine, and no one cares about your drivetrain anymore. We need to find other things that keep us relevant even though the competition is increasing so fast."

----Director of the Innovation Office at A

As digital technologies are becoming increasingly pervasive beyond the digital space, fusing with and fundamentally reshaping the "real" physical world (Nambisan et al., 2017; Baskerville et al., 2020), our understanding of DI needs to evolve and expand, particularly in relation to the physical world, which is typically backgrounded in the digital innovation (DI) literature (Baiyere et al., 2023; Cennamo et al., 2022; Yoo et al., 2012).

This is particularly noteworthy given the extensive DI occurring in incumbent firm settings, such as manufacturing, where firms are increasingly exploring digital opportunities while also responding to new competitive threats stemming from digital technologies (Svahn et al., 2017; Oberländer et al., 2021; Sandberg et al., 2020). A key challenge for these firms is how to extend competitive advantages tied to their legacy *physical core* —a set of technologies and related resources that are closely tied to the production of physical products (Drechsler et al., 2020) —to the digital space. Indeed, incumbents failing to combine physical and digital dimensions in a synergistic way runs a risk of facing a situation where they lose position in both existing and emerging markets when embracing digital technologies (Svahn et al., 2017; Sebastian et al., 2017; Warner and Wäger 2019).

To cope with this risk of losing relevance, recent literature has emphasized a 'digital first' perspective to navigate the innovation process of incumbents (Baskerville et al., 2020; Yoo and Euchner 2020). Digital first refers to the fundamental redevelopment of market offerings from a digital point of view, from the point of conception (Yoo and Euchner 2020). This does not mean that there are no 'physical' dimensions of DI; instead, DI creates value only if it is contextualized in specific time, place, artifacts and actors in the physical world (Baskerville et al., 2020).

Yet, we know little about how incumbent firms might safeguard the relevance of their physical core when going digital first. This is important, since major discontinuity created in such strategic repositioning, while often celebrated in digital innovation and transformation literature, create significant risks to firm survival (Vuori and Huy 2016; Lucas and Goh 2009). Hence, we focus on the following research question: *How can incumbents embrace a digital first*

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innovation approach while at the same time safeguarding the relevance of their physical core technologies?

We draw on an in-depth case study of Alpha (A), an incumbent automotive OEM, and its on-going search for relevance in relation to the digital disruption characterizing the transportation industry setting, most notably shaped by autonomy, connectivity and electrification (ACE) technologies that provide new competitive dynamics as well as opportunities.

2. Conceptual background

2.1. Incumbent challenges in DI

DI refers to the use of digital technology to create novel products (Yoo et al., 2012). Because these market offerings build on digital technology, they create value in a qualitative different way from nondigital products (Nambisan et al., 2017). In particular, while incumbents in industrial settings earned their competitive positions on the basis of a 'physical core' that consists of rare, inimitable, and non-substitutable resources (Barney 1991) with fixed product boundary, companies competing on the basis of a "digital core" in their market offerings (Huang et al., 2022) use a set of digital resources (i.e., digital technology components) that exhibit a 'difference-in-kind' versatility (Yoo et al., 2010) that can be repurposed into new business areas with low adjustment costs (Henfridsson et al., 2014; Nambisan et al., 2017). Consequently, digital technology creates disruptions that urge incumbent firms to alter the value creation paths they have previously relied upon to remain competitive (Vial 2019).

Specifically, DI often builds on value created through the decoupling of product functions from their related physical form or device (Yoo et al., 2010), which breaks the traditional wisdom that value is embedded in product in incumbent setting. Instead, value creation occurs when the offering is recombined, extended, and re-invented in an *ad hoc* network with other digitalized artifacts in a particular context (Lusch and Nambisan 2015; Yoo 2010). For example, the combination of location-based mapping systems, mobile clients and sensor networks makes a physical vehicle an integrated part of an intelligent city transportation solution that responds to different travel demands in a specific time and place. In such an anarchic DI network (Lyytinen et al., 2016), a myriad of previously unconnected actors (e.g., hardware device manufacturers, software companies, content providers, etc.) weave together their individual offerings, business models, and technological architectures to develop a coherent, customer-facing solution (Jacobides et al., 2018) that disrupts the actors' assumptions of a taken-for-granted product and its ecology (Boland et al., 2007). Here, the anchoring point is the system of innovations that materialize a focal value proposition, rather than what a firm is to deliver (Adner 2017). Accordingly, an incumbent firm's physical core has to be fundamentally revisited and rooted in a broader innovation ecosystems in order to extend its relevance to value creation in digital innovation. Failure to do so might place a physical core at the risk of becoming obsolete and even a burden for incumbent survival in their transformation journey (Vuori and Huy 2016; Lucas and Goh 2009). The challenging question is then how incumbents can strategically reposition their core and themselves in a competitive landscape of digital innovation.

2.2. Digital first to maintain relevance

The digital first perspective (Yoo and Euchner 2020) can be seen as a means for incumbents to manage DI and the risk of 'losing relevance' in the digital age. Focal to this perspective is a rethinking of the physicality of DI and the importance of a physical core in the process. Specifically, the assumption is that DI creates value in use that in most cases requires some conversion of digital information into a physical manifestation (Yoo and Euchner 2020), echoing the recent viewpoint that digitized objects (e.g., app, music) always build on specific material bearers (e.g., cell phone, audio equipment) in the real word, which embody or enable the storage, manipulation, transmission, and presentation of digital information (Baiyere et al., 2023; Piccoli et al., 2022). In this regard, incumbents' physical core has potential to maintain useful and serve as a strategic leverage point in DI.

To this end, the physical core should be reconsidered from a digital point of view from the point of conception (Yoo and Euchner 2020). Such digital first repositioning holds a potential to generate value through "hybrid" offerings that are distinct from purely physical- or digital-underpinned offerings, such as reshaping the product meaning as a digital platform to fulfil a package of disparate, evolving and integrated services for a focal business setting (Oberländer et al.2021; Svahn et al., 2017; Drechsler et al., 2020). In this regard, while digital first brings physical dimension back to DI, it implies a major strategic discontinuity in incumbent firms through introducing qualitatively different market offerings. However, we still have a significant gap in our understanding of how this digital first approach could be enacted in a way that at the same time safeguards incumbents' physical core. To this end, we draw on insights from literature on ambidexterity to inform our study of this process.

2.3. An ambidextrous approach to digital first

While the ambidexterity literature has been largely disconnected from 'digital first' and 'DI' studies, it suggests a possible path to pursue a digital first approach. In particular, the extant digital transformation literature (Gregory et al., 2015; Svahn et al., 2017; Warner and Wäger 2019) emphasizes ambidexterity as a necessary capability for incumbent firms to navigate this repositioning process and extend their competitive advantage tied to the physical core in a digital world. At the heart of this capability, incumbents must simultaneously exploit existing resources and explore new opportunities (O'Reilly and Tushman 2008).

Prior research describes two different logics to achieve an ambidextrous management. In one long-established stream of studies, exploitation and exploration are devoted to two conflicting yet interrelated business goals, treating the exploitation occurring upon existing resources as separate from the exploration of new values based on novel resources (Smith and Lewis 2011). Another emerging stream of studies instead regard exploitation and exploration as only seemingly contradictory and as being harmoniously combinable (Gregory et al., 2015; Oberländer et al., 2021). Under this blending perspective, incumbents can shape a sophisticated fused solution to achieve ambidexterity, which echoes to the underlying logic of digital first perspective. Hence, in this study, we draw upon this blended ambidexterity as an analytical lens to trace and understand how an incumbent firm goes digital first.

3. Method

Empirically, we draw on an extreme (and accessible) case that could provide rich information about the variables of interest in real-time rather than post-hoc (Gerring 2007): the digital first pursuit of A, an automotive firm established in 1891. The process through which A made efforts to maintain the relevance of its physical core in the face of the new technological opportunities (2015- 2023) constitutes the case on which we focused. In total, we employed a combination of interviews (N=65) and field observations (11 observations in Sweden and Singapore).

Following a grounded approach (Gioia et al., 2012), we engaged in a multi-stage data analysis that involved several iterations between emerging concepts and consultations of the literature. In line with Gioia et al. (2012), we began with holistic reading and identifying first order codes that were close to our empirical transcripts, notes and archival data. Guided by the question 'what activities did A perform to understand what role their core assets and capabilities tied to the "Truck" could play in relation to the new digital opportunities and threats?', this open coding revealed that some types of activities were repeated across units and teams. We clustered the 1st round open-ended descriptive codes (e.g., disconnecting from the firm's R&D perspective, identifying material bearers of an ecosystem solution) into 2nd order themes (i.e., context probing, role probing, physical gripping, resource mapping, digital enabling, and physical embedding). We iterated this process of coding and relabeled the clustered codes (themes) based on consultations of the literature (Gioia et al., 2012). At the end of this step, we arrived at a conceptualization including three aggregate dimensions (Gioia et al., 2012) representing three key processes: ecosystem probing, physical anchoring, and phygital infrastructuring. In the final step of analysis, we specified and conceptualized the possible relationships between the three key processes; these relationships were indicated by the earlier substantive analysis and were, therefore, highly fitted to our data. The outcome of this stage helped us generate a conceptual model of going digital first with strategic continuity in Figure 1.

4. Developing a digital first approach in the incumbent firm: The case of A

A earned its position as a leading original equipment manufacturer (OEM) in Sweden after decades of development. However, the recent advance in digital technology underpinning autonomy, connectivity, and electrification (ACE) developments placed the company in a new position, wherein the preexisting assets and capabilities developed around truck production began losing their relevance in relation to the future expected competitive landscape. To rebuild the firm's relevance in this disruptive time, A initiated a series of innovation experiments to redevelop their market offerings from a digital point of view. Below, we present the three practices that together composed the mechanisms driving this digital first process through which A re-established the relevance of its physical core between 2015-2023. We illustrate the practices with examples repeated across different innovation initiatives studied (more data available upon request).

4.1. Ecosystem probing

The first practice that had a salient role in A's digital first pursuit was what we refer to as *ecosystem probing*. In this practice, A disconnected from its internal R&D perspective when making sense of new technological opportunities (i.e., digitally-enabled solution spanning disparate products and firms), and took a systematic point of view to probe the demand landscape of wider innovation ecosystems in transportation. Approaching the 'system' rather than departing from internal pipelines was however not what A was used to doing; "we need to learn this so that we can find out what needs we should try to care about", as a partnership manager said. To this end, A engaged tentatively in a large set of external collaboration initiatives, often driven locally by different internal departments, thereby gradually learning what a "system" or "ecosystem" approach meant and what it could look like. An illustrative example occurred in 2021, when the innovation office at A initiated the SIUTS (Sustainable & Integrated Urban Transport System) project aiming to "develop a sustainable and efficient way for urban freight transport" (SIUTS project plan).The SIUTS project was located in the R&D center of A, which by tradition explored new possibilities from a technology-centric perspective, departing from the in-house capabilities and next possible version of existing product lines. In contrast, the SIUTS project took another approach: reorienting the exploration away from an existing, internal and product-centric roadmap to an experimental, external, and solution-centric path. However, taking this new path was challenging because there were no available guidelines regarding how to depart from a 'system' view, or how to 'explore and understand the ecosystem'. Hence, the SIUTS members experimented with a set of activities aiming at understanding the stakeholder needs and positions. "Empathizing workshops" represented one such activity, where the SIUTS project engaged more than 30 practitioners i.e., from OEMs, transport companies, food suppliers, municipalities, digital service providers, technology companies to understand their everyday working lives, needs and expectations. By doing so, the SIUTS project took an outside-in perspective to explore opportunities afforded by new digital technologies. As described by the project director:

We want to understand the transport system. If you want to look into the change in that area of space, then you cannot be tech-focused. And A is always oriented around the technology, at least in R&D. So then we need to push our limits and see our opportunities beyond the knowledge space we have today…We need to be creative and add on good ideas and build great ideas together with external partners that share the same vision and see the same future. Otherwise, we just build another nice truck again, which we are already quite good at.

Although the outwards focused activities were unusual and somewhat uncomfortable and awkward for the participants, they generated significant insights. For instance, in a 'switch hat' exercise run by the SIUTS project, 14 ecosystem actors were asked to list the needs and benefits of another actor in relation to the vision of running urban transport in a radically new way. The meeting ended with the participants understanding what the new digitally-enabled solution could actually mean and look like. Other activities run by other initiatives similarly taught A about the highly varied needs and expectations among the multiple ecosystem participants involved in a focal business scenario.

The multiple ecosystem initiatives also provided A the possibility to experiment with different roles in relation to those ecosystems and solutions. Despite its leading position in truck manufacturing, A made great efforts to not automatically assume a leadership role when approaching the new value proposition tentatively discussed among diverse stakeholders in a focal business scenario. Specifically, while A has strong barging power in the traditional supply chain of vehicle production, it was no longer the case when developing radically new solutions with vast scope and scale, such as "a sustainable and efficient urban transport system". As such, the interaction mode with external partners changed from hierarchical, one-to-many relationship to many-to-many relationships including mutual dependencies that recast the historical roles and supply chain deliverables of the stakeholders involved, and required new and more coordination efforts from different stakeholders. For example, in on-road charging service for autonomous truck transport, "*A is no longer the important one; It is the energy suppliers who set the rules and tell us what we need to in order to be able to integrate with their charging station*", as a product manager explained. In this process, A experimented with multiple commitment modes in the different projects it engaged in. For instance, when the customers already developed some knowledge on autonomous haulage transport in mining industry with a third-party supplier of transport management system, A decided to integrate with their existing system as a partner for the final solution development. In another innovation initiative aiming for a quite radical solution: "a fully autonomous public transport solution" for the city-state of Singapore, A shared the orchestration role with other partners in a dynamic fashion for leveraging their expertise in developing vehicles with in-built intelligence and self-driving functionality.

3.2. Physical anchoring

An increasing understanding of stakeholder demands in the wider transportation system opened up a broad solution landscape for A to dig into, including digital trucks, fleet management, on-road service, digital road freight management, transport management systems, and digital supply chains. It was therefore important for A to choose which areas to contribute to. In this process, one key criterion that different initiatives used was the possibility to locate the physical foothold of the digital-enabled solution, wherein A's preexisting resource base could be leveraged but also reimagined. We refer to this kind of practice pattern as *physical anchoring*. In the example of SIUTS project, this manifested in a specific physical design package focused on purpose-built vehicles, dynamic storage points, modularized load carriers, and their necessary connectivity and automation capabilities that enabled the consolidation of fragmented fright flows over time and space. As explained in the SIUTS project executive summary:

With digitalization in the transportation industry, goods must still be moved physically by vehicles in the future, which in many ways will differ from today's solution. For example, autonomous multipurpose vehicles that can be modularized into different shapes and sizes are required for 24/7 delivery services in cities. As the vehicles go through this transportation process from shippers to receivers, it potentially becomes the data platform to enable and integrate diverse in-vehicle (e.g., connected goods, box solution for refrigerated goods) and out-vehicle (e.g., last-mile off-peak delivery, joint loading) services.

Many members in A's innovation initiatives underlined that identification of material bearers was an important means to create linkage between emerging ecosystem solutions and the resources underpinning A's existing physical offerings. For instance, instead of reinventing a multi-purpose autonomous vehicle inspired by ecosystem probing from scratch, A could largely draw upon its existing modular system to adapt the truck loading components for different pickup and delivery solutions, upon which requisite autonomy-specific components such as cameras, lidars and radars were integrated by A or partners to provide self-driving capability. Similarly, A's expertise in modularization (e.g., partitioning complex systems, hiding internal components and focusing on interfaces) was also useful in the generation of ideas about how new kind of seats, self-cleaning components, or in-vehicle cameras (produced by A or external partners) could be added or removed to public transport buses, and how interfaces could be developed to those new components.

Meanwhile, the new digital capabilities specified for the functioning of material bearers drove A's attention to the need to also renew existing IT resources locked in existing physical offerings, such as data. A salient example is the reassessment of the role of truck data for A's value creation. Previously, the abundant data from truck fleets (e.g., about driving behaviors, transport patterns, fuel consumption) were created and only used by the R&D department to improve the product design internally. However, with the new demand for connectivity emerging across innovation initiatives, there was a growing consensus in A that truck data was a prerequisite for new kinds of externally provided services, requiring extensive access by and interoperability with partners and clients in any transport solution. A similar renewal demand was evident in the Singapore transport initiative, wherein A and external partners invested heavily in addressing how existing data ownership architectures and existing data generation hardware (sensors, cameras) tied to specific vendors and product lines needed to change, to allow the data to be partly and safely shared in order for transport to be optimized in cities. In doing so, A took the first step to link new digital opportunities back to its established core business.

3.3. Phygital Infrastructuring

To make existing resources relevant to the future digital world, A reconfigured and connected its resources to wider infrastructures including both physical and digital layers, which were intended to serve as the foundation of the aimed digital solution demanded by the wider transportation ecosystem. We refer to this third practice as *phygital infrastructuring*. In each innovation imitative we traced at A, this practice proceeded through two parallel activities over time. In the first activity, A redeveloped its trucks into more open data sources able to generate data insights to multiple diverse stakeholders in the transportation ecosystem. For example, in the SIUTS project, A worked with logistics analytics companies to test different sensor technologies for creating entirely new data that did not exist in the current transport system. A actively developed open APIs and communication standards to make the new data connect seamlessly with other stakeholders' offerings. Both endeavors were supported by large investments in the wider infrastructure required in areas of expected implementation of the aimed for sustainable urban freight transport, such as control towers (operation centers for remote monitoring), location-aware devices for truck tracing on roads, and city transfer hubs with smart blocking systems. Together with its external partners, A thus moved towards building a public, shared digital layer upon and interacting with the physical layer, which supported collective data creation and collection for the functioning of future transport solution. As explained by the SIUTS project manager:

Obviously, our customers always have different brands of trucks and use different partners' services. So, if we try to sell this as an 'A solution' only, nobody is going to buy it. Hence, it is necessary to make our truck interoperable with different types of services that you can get. To this end, we need to open, standardize and industrialize the digital infrastructure [referring to the wider digital infrastructure beyond A's internal digital infrastructure] as much as we can in the back end so that we have the flexibility to serve different needs and adapt to specific frontend data-driven solution for almost every customer.

In the second activity, A actively tapped its 'digital truck' into the key stakeholders' individual transport systems. For instance, the SIUTS project developed and tested an unmanned delivery solution in a city by building upon the existing delivery systems of multiple digital logistics partners. Here, A integrated its truck management system into the major end-receivers' good management system and store terminal system to further provide an unmanned reception solution for customers. In addition, A made agreements with the main energy suppliers in Stockholm city to integrate with their battery charging stations so that the A trucks were supported by a reliable and attractive on-road service during freight transport. As such, A embedded its digital truck into the whole loop of an urban transport solution, a firm step to transform A's existing offering as a key building-block of future digital transportation ecosystem.

In the initiative for autonomous public transport for Singapore, efforts were further made to specify how A's self-driving vehicles would plug into the Singapore government's existing intelligent transport system (ITS) system. The ITS system included cameras on roads and a remote monitoring center where operators were notified of divergences/accidents on roads. Further, expanding its in-vehicle communication, A and partners made efforts to ensure vehicle-to-vehicle and vehicle-x communication fitting with and extending Singapore's existing physical and digital infrastructure. This required A to adjust to emerging standards and other partners' preferences since there were no agreed standards for communication between vehicles produced by different vendors at the time. As a manager in data & mobility services noted:

We have a particular emphasis on partner-driven services. Instead of using in-house development for customers, they are more about how we can make our technology work with other market stakeholders' technologies, and what solutions we need to coordinate together to make a complement system. By doing so, we will make sure that there is infrastructure ready for you to start operating, and we are the people who know how to service autonomous vehicles. So, we kind of become the core platform that provides everything to support your functioning and it is through us that you will make money.

4. A process model of developing digital first capability

Our inductively derived model shows how three recursive mechanisms—*ecosystem probing*, *physical anchoring*, and *phygital infrastructuring*—together produced an enhanced digital first capability through which A safeguarded the relevance of its physical core in the digitally driven industry transformation (see Figure 1).

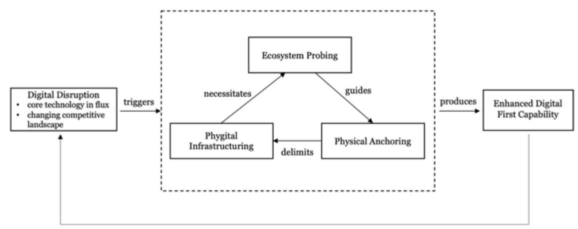

Figure 1. A process model of going digital first with strategic continuity.

At a general level, the mechanism of *ecosystem probing* refers to the process by which an incumbent senses new technological opportunities in wider innovation ecosystems through *context probing* and *role probing*. First, *context probing* involves activities through which the incumbent understands and defines future demands in multiple but specific innovation ecosystems. Second, *role probing* involves activities through which the incumbent experiments with multiple, parallel participation roles in different innovation ecosystems.

A's ecosystem probing echoes past studies suggesting that digitalization spurs change in an incumbent's organizing logic (i.e., the rationales that product organization offers product functions or services) from an internal production-oriented logic to an external ecosystem-centered logic (Gawer 2014;

Sandberg et al. 2020; Svahn et al. 2017). Dominating as an OEM product platform for decades, A was used to working with a set of stable, shared internal resources to create derivative products characterized by a fixed feature scope and market boundary (Nambisan et al., 2017). However, digital technologies open new options for solutions design at ecosystem level (Jacobides et al., 2018), where both the scale and scope of the innovation are extended beyond single product architecture to loosely coupled product systems spanning traditional industrial boundaries (Lyytinen et al. 2016; Nambisan et al. 2017). In this regard, a digitally-enabled ecosystem solution requires new collaborative arrangement around a layered modular product architecture (Yoo et al., 2010), wherein an array of individual offerings (i.e., digitized products and services) are developed and integrated into a joint, focal, customer-facing value proposition in a real-world context, a contextual embedding process highlighted by Lyytinen (2022).

As A probed the wider demand landscape in transportation industry, it actively engaged in both orchestrator and follower roles in different innovation ecosystems, which is rarely noted in digital ecosystem literature. While emphasizing the relevance for firms to participate in digital ecosystems, the literature implicitly assumes that firms pursue one rather than multiple different roles when building or approaching ecosystems. In particular, prior studies implicitly point at the orchestrator role, encouraging firms to strive for network effects and winner-take-all outcome in digital markets (Parker et al., 2016; Henfridsson 2020). Given its governance role in an ecosystem, the orchestrator enjoys significant advantage in value capture by reaping the lion's share of gains in an ecosystem (Gawer 2014). In the case of A, however, the incumbent probed innovation ecosystems mainly from a value creation perspective, that is, a strong aspiration to be part of a coherent, digital-enabled solution supported by various complementary offerings together. To this end, being open to various different roles enables the incumbent to explore multiple ecosystems, through which the incumbent can potentially learn how to redefine and refresh its offerings in a new relationship to other participants' offerings. In other words, ecosystem probing serves as a means to explore the versatility (Huang et al., 2022) of existing resources in the future demand landscape to the maximum.

Physical anchoring refers to the process by which an incumbent creates bridges between emerging ecosystem solutions and its core resources tied to physical offerings through *physical gripping* and *resource mapping*. First, *physical gripping* involves activities through which the incumbent locates the physical footholds of emerging ecosystem solutions. Second, *resource mapping* involves activities through which the incumbent maps existing resource base (e.g., technologies, hardware, software, data, partner relationship) to potential physical footholds it is able to develop. Together, these activities let the ecosystem solutions inform the redesign of physical artefact in a way that makes the incumbent's offerings of the key physical foothold in innovation ecosystems.

A's physical anchoring was based on the fact that every DI has one or more material bearers (Baiyere et al., 2023) that form the backbone of value creation and capture. Material bearers include IT assets[1] in terms of physical computing systems that enable the storage, manipulation, and transmission of bitstrings in terms of cost, speed reliability and so on (Baiyere et al., 2023), and more generally, the physical footholds that enable a conversion of digital information into a physical manifestation which can be consumed by users in the real world (Yoo and Euchner 2020). For instance, digital insights about the consumer demands are converted into design and become a physical product which is of value to users. Anchoring to the physical footholds commonly shared among different innovation ecosystems is vital to rebuild the relevance of incumbents in two aspects. First, apart from thinking of it as a concrete materialization as in prior studies, a physical foothold can also serve as a design pattern that is part of a generic solution to a recurring demand (Henfridsson et al., 2014). In the case of A, multiple requisite physical footholds (e.g., rebuildable truck, smart loading machines, city hub ideas) are identified to provide a high-level, generic description of how to move goods or people from place A to B. These physical footholds have an abstract function, suggesting a cluster of patterned operations, purposes, services or components to respond to a commonly occurring demand across ecosystems (e.g., urban delivery, highway transport, unmanned transport, urban mobility). Firms, therefore, can materialize and specialize a generic design pattern in different settings by recombining it with other design patterns in a contingent fashion (Henfridsson et al., 2014). As such, physical footholds are the building block of value

[1] We define IT as the tangible resources including data, software and programs that are locked into the firm's physical systems, while digital is informational entities that are modularized and exposed through a programmatic, non-material interface (Piccoli et al., 2022).

creation in braoder innovation ecosystems, no matter what focal value proposition in question.

Second, when instantiating these abstract patterns or concepts into specific settings with actual products, the incumbent can get clear clues to link the new artifact design back to its wider set of resources (e.g., organizational, physical, IT) tied to its physical offerings. This occurs as the incumbent finds ways to reuse exiting resource base in the further development of its products as part of identified physical footholds, which in turn often requires the renewal of those resources. For instance, in the setting of unmanned delivery in city, A could rapidly adapt its existing trucks running in the city to multi-purpose vehicles by reusing its expertise in modular development system. At the same time, the unmanned requirement helped A figure out the new digital capabilities (e.g., connectivity, autonomy) to develop, which required to lift its emerging expertise in robotics and adjust its data resources to be more open and interoperable. Together, this helped A to rebuild the relevance of its physical offering to support future transportation landscape. In this regard, physical anchoring enables an incumbent to not only leverage its legacy production resources that have economics of scale advantage, but also develop specific digital resources that can maximum value creation when combining with the leverageable legacy resources. Accordingly, physical anchoring helps an incumbent to seek out a most relevant development path that continually exploits existing resources in an open-ended landscape of DI.

Finally, *phygital infrastructuring* refers to the process by which an incumbent makes the physical footholds it developed a part of the physical and digital infrastructure that contributes to the functioning of emerging ecosystem solutions. This occurs through *digital enabling* and *physical embedding*. First, *digital enabling* involves activities through which the incumbent leverages the physical footholds it developed as the open data source for generating digital insights shareable among diverse ecosystem actors. Second, *physical embedding* involves activities where the incumbent reconfigures resources to tap the physical foothold it developed into broader ecosystem actors' individual offerings. Together, these acts of inviting/ 'letting in' (pull) and plugging into (push) broader external actors' resources respectively facilitate the renewal of the incumbent's offerings by serving as the junction wherein physical use experience is converted into digital insights and vice versa (Cennamo et al., 2022). As such, the incumbent's product changes to be the foundation to create computed use experience (Baskerville et al. 2020) in an industry transformed by digital technologies.

Digital enabling is not a simple digitizing process through which a physical information-carrying object is converted into bitstrings. In such situations, digitizing is primarily an internal process following an engineering paradigm where a digital object is created to represent physical activities and objects in the real world. In the automotive industry, for instance, OEMs created anti-lock braking systems that use sensors to trace the brake pressure to prevent the wheel from locking up, infotainment systems for navigating and voice commands, and telematics systems for monitoring vehicle performance and driver behavior (Henfridsson et al. 2014). In these cases, digitizing generates a 'box' of hardware and software-a tight coupling between bitstrings, their operations and material bearers-which captures specific flows of data and its processing tied to specific physical products (Baiyere et al., 2023). As noted by Ross (2017), such digitization of everything will not, by itself, make a company a digital business. In the case of A, however, the digital enabling process goes beyond the box in the sense that the digital object (e.g., digital truck with open API interfaces) is accessible to diverse ecosystem actors across contexts whereby the tight connection between digital trace data and its material bearer (e.g., truck) could be broken. In doing so, an incumbent's offerings become the enabler to trigger waves of successive innovation in broader ecosystem contexts, making the incumbent a digital business (Baiyere et al., 2023). In other words, digital enabling goes beyond the creation of digital representation of existing, known products, actors and operations (i.e., digitization) by enabling digitalization (Lyytinen 2022) and generativity (Yoo et al., 2010) wherein a firm's digital resources can be continually used by future, partly unknown users.

To become a fundamental part of the infrastructure of broader innovation ecosystems, an incumbent's offerings not only need to be shareable among and enable users, but also must be physically embodied, scalable and economically sustainable (Piccoli et al., 2022). By engaging in physical embedding, i.e., actively connecting the digitally enabled physical footholds it developed to different actors who occupy the key positions in the flow of activities across an innovation ecosystem, the incumbent leverages its scaled physical resources to tap its offerings into various ecosystem actors' individual products and services. In this regard, physical embedding serves as an interconnecting activity that taps into the value path of other actors. While prior literature in DI conceptualizes such activity as a competitive strategy (e.g., envelopment, piggybacking, path channeling) to capture value from others (Eisenmann et al., 2011; Henfridsson et al., 2018; Parker et al., 2016), we show that an incumbent firm conducts it from a value co-creation perspective whereby diverse actors can draw upon the physical foothold it developed to gain digital insight into users' physical consumption precisely and in a timely way. This, in turn, facilitates to develop a systematic, digital-enabled solution that shapes and creates new user experience in the physical setting.

In summary, we conceptualize the three mechanisms as ongoing and mutually shaping. In combination, they represent a digital first approach involving a continuous oscillation between "reaching outwards" (through ecosystem probing), anchoring inwards (through physical anchoring), and securing and reinforcing one's role in the infrastructural base of emerging innovations (phygital infrastructuring). Specifically, ecosystem probing *guides* physical anchoring by identifying the ecosystem solutions that an incumbent firm needs to anchor back to its physical core. Physical anchoring further *delimits* the way to execute physical infrastructuring by specifying the physical footholds that the incumbent is able to develop and digitally enable, and delineating the scope of external actors who build upon the developed physical footholds. Over time, the necessity to adapt phygital infrastructuring for the evolving, open-ended landscape of DI (Henfridsson et al., 2018; Nambisan et al., 2017) propels the incumbent to re-probe the broader ecosystems again. In other words, phygital infrastructuring *necessitates* ecosystem probing.

The three mechanisms drive an incumbent's digital first transformation in the sense that the existing physical offerings are redeveloped from a digital point of view since the point of conception (Yoo and Euchner 2020). Specifically, the existing physical core technology and related resources are renewed and reconfigured with digital technology and resources to function seamlessly as part of an ecosystem solution (e.g., off-peak delivery, autonomous transport in city), rather than a single, stand-alone product (e.g., a truck). Such hybrid offerings shifts from a goods-dominant logic to delivering functions-as-a-service (Lusch and Nambisan 2015) by building upon a repeatable pattern of actions that share among different projects—that is, repositioning the physical core to be the foundation of the functioning of broader innovation ecosystems. This *enhanced digital first capability* therefore serves as a generalized principle (Nambisan et al., 2017) to solve an incumbent's 'losing relevance' risk while extending its strategic continuity at the same time by safeguarding the relevance of physical core in multiple future-oriented business scenarios.

5. Implications

Our process model contributes to the DI and transformation literature. First, we develop a process model explaining how an incumbent develops an enhanced digital first capability in relation to digitally driven industry transformation. The process model unpacks three mechanisms underpinning digital first offering development: ecosystem probing, physical anchoring, and phygital infrastructuring. Prior work notes the role of physical artifacts as the material bearers that form a bedrock for digitalization (Yoo et al., 2012; Baiyere et al., 2023; Piccoli et al., 2022), as well as how digital technologies may fundamentally shape and reconceptualize physical artifacts in a digital first world (Baskerville et al., 2020). Although this research speaks to the importance of physicality of DI, it does not specifically examine the underlying process by which the physical artifacts are leveraged and maintain their strategic continuity when going digital first .

Second, the three mechanisms provide a vivid and deep elaboration of how exploration and exploitation are harmoniously combined into one process, as incumbents search for relevance in the disruptive times shaped by digital technologies. Specifically, when an incumbent explores new opportunities afforded by digital technologies through ecosystem probing, the preexisting physical core can serve as a strategic leverage in a way that helps to sense viable opportunities through physical anchoring and seize them through phygital infrastructuring. Hence, we show how incumbents enact a cognitively sophisticated 'single solutions' (Gregory et al., 2015) to achieve ambidexterity.

Finally, our findings also speak to recent conceptualizations of digital transformation as an ongoing process of strategic renewal wherein incumbents embrace new digital technologies (Warner and Wäger 2019). Echoing to the emphasis of resource renewal in supporting incumbents' transformation journey in prior studies (Drechsler et al., 2020; Oberländer et al., 2021), we outline how resources can be renewed an orchestrated way, allowing incumbents to resolve the competing concerns between the 'old' and 'new' in such situations (Svahn et al., 2017).

In addition to the theoretical implications outlined above, managers in incumbent firms can learn from our findings as they practically struggle in reenergizing their physical core beyond the relevance to existing revenue stream and preventing it from becoming a burden in digital transformation. To this end, the three mechanisms provide practical guidance to maintain the strategic continuity of a physical core as a leveraging point for digital first move. Despite valuable contributions, our study is located in an ongoing digital transformation journey at A without clearcut final outcomes at this stage. However, the enhanced digital fist capability developed in this process has resulted in a general innovation pattern that brought forth a plethora of novel initiatives to move forward. In this regard, the three mechanisms are likely to play out in other incumbent settings established with a physical core.

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