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Coordinating an Intelligent Circular Economy: Fundamental Guidelines for Digital Product Documentation

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1. Abstract

In order for firms to implement the Circular Economy, and close all material and energy cycles, connections are needed not only within but also between multiple Industrial Ecosystems. To enable such complex interconnections, the European Union is preparing legislation to enforce the use of digital product passports (DPPs). These are verifiable collections of data about products' composition, environmental footprint and opportunities for preventing waste. The notion of the DPP relies heavily on a suitable digital infrastructure, and it opens the possibility of using the power of artificial intelligence (AI), to optimize circular production within and between Industrial Ecosystems. The benefits of DPPs will only be attained if their design, knowledge engineering, and implementation is well-orchestrated. The purpose of this paper is to develop a set of guiding principles for the orchestration of DPPs, based upon a trans-disciplinary analysis, that form a theoretical basis upon which a business plan and further research can be completed.

2. Introduction

As part of its Green Deal, the European Commission proposes the introduction of digital product passports (DPPs) in the European Single Market as an enabler of circular business practices leading to efficient use of materials and CO2 emission reduction (European Commission, 2022). The proposed regulation will mean that products can only be sold or put into service in the European Union if a DPP is available, providing an accurate and verifiable set of information about the products' environmental sustainability, intended to help consumers and businesses make informed purchasing choices. Additionally, DPPs are intended to facilitate repairs and recycling and improve transparency about products' environmental impact during production and throughout their entire lifecycle. DPPs will also enable public authorities to assess products' compliance with sustainable production and usage regulations, as they will include data to enable the tracking of any substances of concern throughout the products' lifecycle (Berger, Schöggl, & Baumgartner, 2022).

Implementing DPPs in practice presents a complex challenge to firms in industrial ecosystems to maintain high-value and high-quality material and energy cycles (Korhonen, Honkasalo, & Seppälä, 2018) as their supply chains extend around the globe, covering multiple administrative areas (Hopkinson, Zils, Hawkins, & Roper, 2018). Additionally, in order to close all necessary energy and material cycles, connections are required not only within such ecosystems but also between ecosystems, as waste from one industrial process may become input for a previously unrelated industry (Liu, Ma, & Zhang, 2012).

Scholars argue that through the digital transformation of industrial ecosystems, knowledge engineering will leverage data to generate sustainability impact by analyzing supply chain bottlenecks, taking autonomous decisions for production planning to shorten lead times, and improving supply chain flexibility and robustness (Feldt, Kontny, & Wagenitz, 2019). In this vision, knowledge engineering makes use of the data provided by DPPs, to enable a strategic transition to a Smart Circular Economy, a new socio-economic paradigm (Kristoffersen, Blomsma, Mikalef, & Li, 2020).

Despite the promise of DPPs, research has paid limited attention to the challenges of their implementation in practice (Adisorn, Tholen, & Götz, 2021). Due to the complexity of production processes and the new interconnections that need to be created across and between resource-intensive

industries, no single industrial ecosystem can organize this alone (Walden, Steinbrecher, & Marinkovic, 2021). For the effective transition towards a CE, it is vital to understand how to orchestrate DPPs such that all relevant parties gather and provide access to the necessary data. The concept of orchestration in this context refers to the arrangement and direction of deliberate, purposeful actions by manufacturers in order to implement and exploit DPPs (King, Timms, & Mountney, 2022). For example, this can include extending industrial partnerships (Gualandris et al., 2015), managing the digital technology infrastructure (Berger et al., 2022, Chauhan et al., 2022), developing and maintaining DPP governance (Janssen et al., 2020), and promoting value-creation and value-capture activities across and between the industrial ecosystems (Lüdeke-Freund, Gold, & Bocken, 2019). Without clarity about the key issues relating to the orchestration and implementation of DPPs, negative unintended consequences for the transition to the CE may ensue.

As such, the purpose of this paper is to address the orchestration of DPPs within and between industrial ecosystems to enable effective knowledge engineering in the transition to the CE. In this context, the orchestration may be coordinated by large manufacturers themselves (Parida, Burström, Visnjic, & Wincent, 2019) or by independent intermediaries with the resources to bring the relevant parties together (Blackburn, Ritala, & Keränen, 2022). My research question is:

What are the critical factors in the orchestration of DPPs that can enable knowledge engineering to boost circular practices within and across industrial ecosystems?

In order to answer this research question, a transdisciplinary, innovative approach is adopted as a methodological foundation. Given that CE and DPP have not yet been implemented at a large scale and both are multifaceted concepts, research in this area requires forward-looking and holistic approaches (Hofstetter et al., 2021). Therefore, transdisciplinary analysis is suitable because it goes beyond discipline-based approaches, is typically participatory, future-oriented, holistic, and transcends individual domains and practices (Bliemel & van der Bijl-Brouwer, 2018, p. 3). In this paper, the integration of perspectives from multiple disciplines leads to the development of a set of guiding principles and a framework to explain the orchestration needed to successfully implement DPPs in practice.

This applied and conceptual paper aims to be a step toward structuring the effective orchestration of DPPs. The guiding principles that we develop will help to nurture dialogue toward the understanding of key concepts, such as the use of DPP data for knowledge engineering for the improvement of circular business practices. These principles will help other scholars develop focused research into DPPs in the formation of models, analysis of case studies, data collection efforts, and more. In their own right, the framework and guiding principles provide a clear foundation for theorizing on the orchestration of DPPs, to enable knowledge engineering in order to improve circular practices within and across industrial ecosystems.

3. Marketing Analysis

To provide a conceptual and critical view on the implementation of DPP as a mechanism to facilitate the transition to CE, we adopt a transdisciplinary innovation approach where insights and perspectives from different disciplines are integrated to develop visionary guiding principles. Transdisciplinary innovation approaches go beyond discipline-based approaches; they are typically participatory, future-oriented, holistic, and systemic and transcend individual domains and practices (Bliemel and van der Bijl-Brouwer, 2018, p. 3). Such approaches are recommended to better frame and understand real-world problems, provide actionable insights for the pursuit of sustainable development, and integrate a wide range of stakeholders for addressing complex problems (Brennan et al., 2021). As the development and implementation of DPPs are in their infancy, there is a need for critical, transdisciplinary views to provide a roadmap for a future where a fully operational circular economy is underpinned by digital product passports.

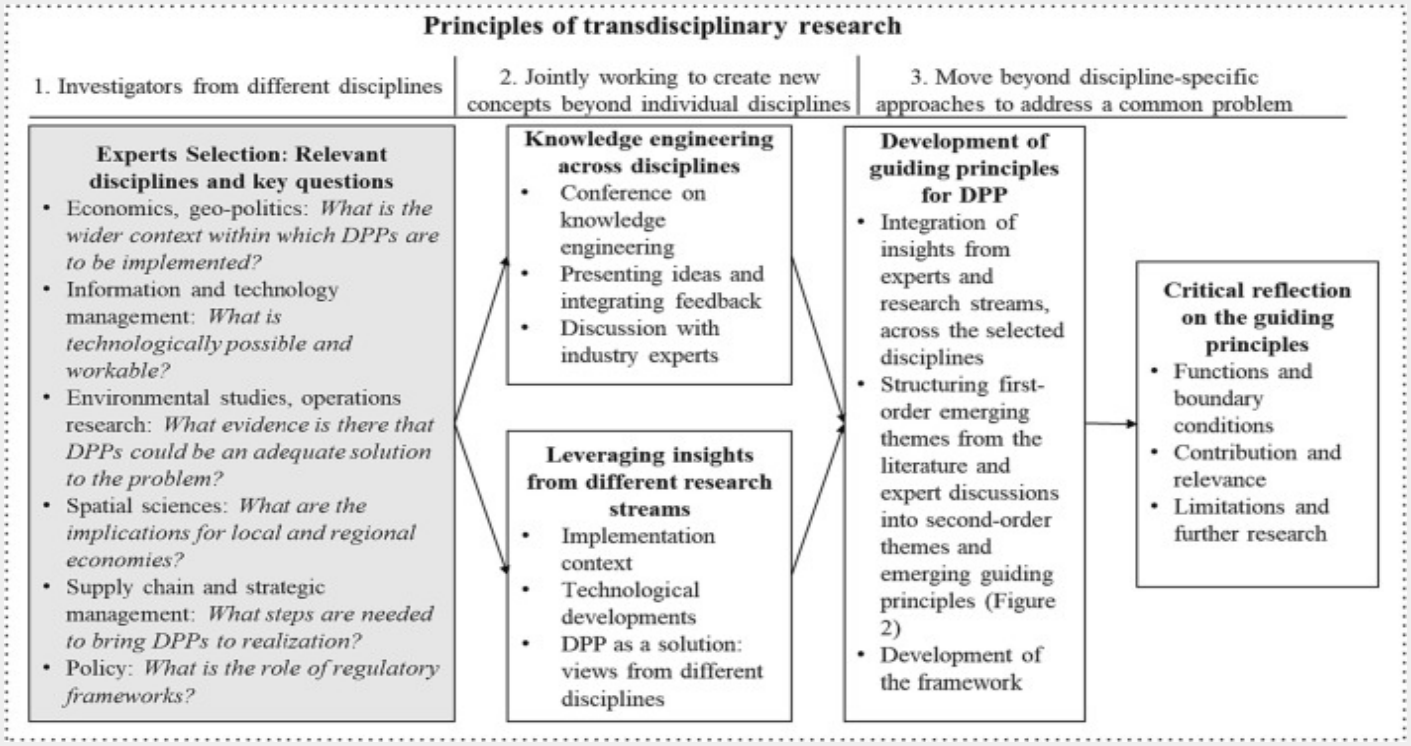

Figure 1 illustrates the formulation of guiding principles for Digital Product Passports through a transdisciplinary approach.

The transdisciplinary research approach is illustrated in Fig. 1. Transdisciplinary analysis distinguishes itself from interdisciplinary research through its focus on three aspects: 1) the existence of investigators from different disciplines; 2) the joint work of the experts to create new concepts beyond individual disciplines; and 3) addressing a common problem and developing approaches that integrate insights from different disciplines (Harvard School of Public Health, 2022). These three steps were followed during the execution of this research, as shown in Fig. 1. First, a selection of experts from relevant disciplines was made by the initiator of the project. The fields of sustainable supply chain management and spatial sciences mainly add to the discussion on the wider context in which DPPs will be implemented. The field of information management is involved in providing in-depth knowledge on enabling Digital Technologies for the DPP landscape, presented in three distinct tiers according to the specific functionality they enable: i) data collection; ii) data curation, processing, and sharing; and iii) data use and exploitation. A senior practitioner from a Dutch applied research and technology organization is involved to engage with developments in practice and with ongoing policy discussions. The author has experience with CE through the lens of their particular discipline. Following Jaakola (2020), we aim to link previously unconnected or incompatible constructs in a novel way.

Second, to actively engage the experts in a joint exchange, the author has participated in a conference on knowledge engineering where the goal was to integrate insights from different domains and create new knowledge to better understand digital knowledge engineering.

Third, the current insights from the literature and from the expert discussions are structured into first-order emerging codes on the socio-technical transition to CE which are grouped into second-order themes. These emerging themes form the basis of the guiding principles which integrate discipline-specific insights through joint exchange and interactive discussions as well as review of existing literature. The guiding principles presented in Fig. 2 are organized into a framework which provides a theoretical basis for scholars and practical direction for managers, because this allows us to frame the implementation of DPP toward a CE such that multiple scientific and societal views are recognized (Brennan et al., 2021). After presenting the emerging framework, a critical reflection on the function, relevance and boundary conditions of the guiding principles is again conducted jointly by the team of experts.

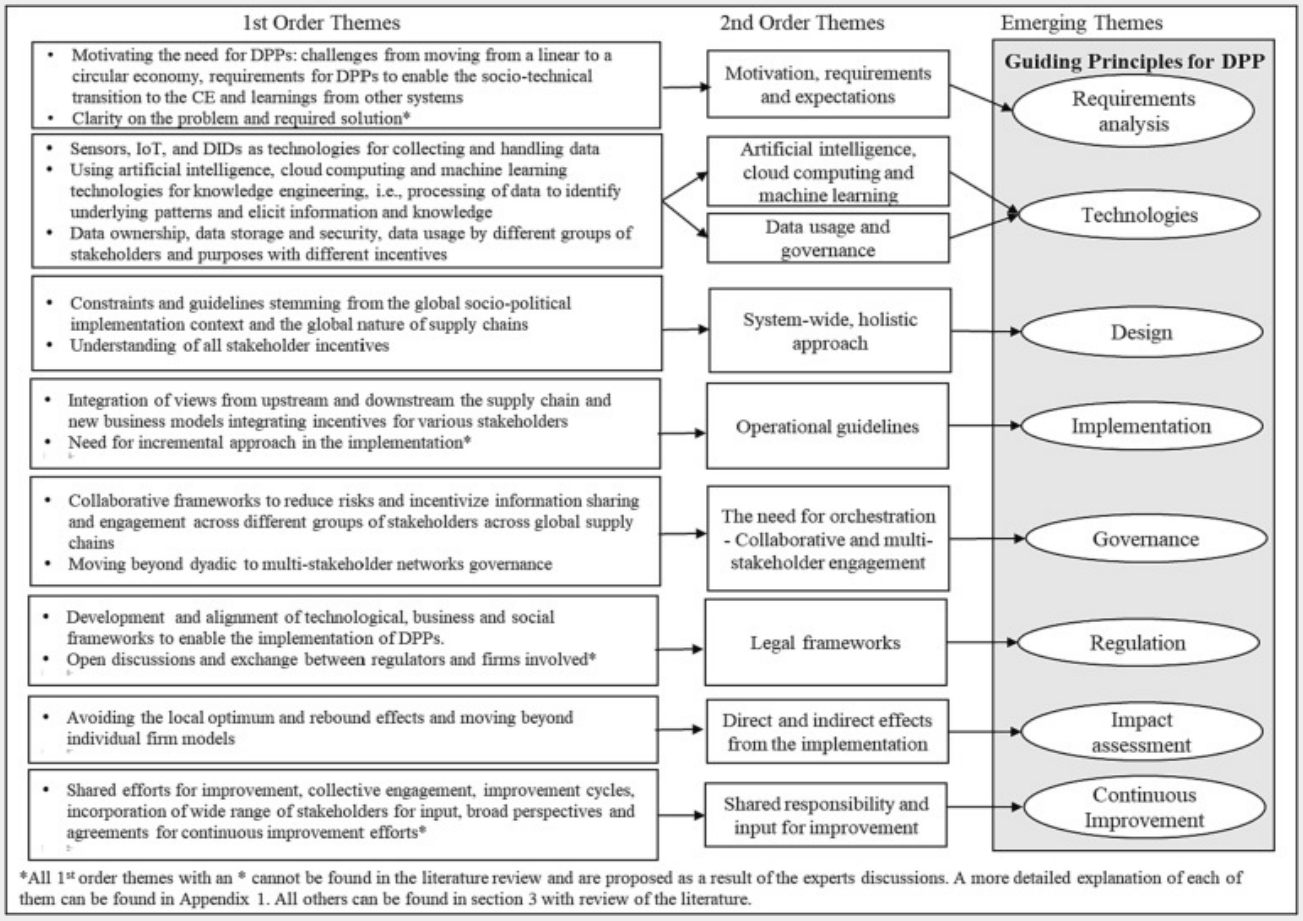

Figure 2. Formulation of guiding principles: incorporating discipline-specific insights through collaborative exchange and interactive discussions.

3.1 Motivation for digital product passports in circular Economy

The Circular Economy (CE) is based on fundamental underlying concepts, such as introducing cascading loops in the flows of materials, that stem from the 1970s era when major schools of thought were established that sought to provide a systemic vision for transitioning to a sustainable economy. Cradle to Cradle, Biomimicry, Industrial Ecology, Natural Capitalism, and the Blue Economy represent major schools of thought, each assuming a different approach to achieving the transition. Indicatively, while Cradle to Cradle focuses on changing design practices for endless product life cycles, Biomimicry looks to nature for successful models of processes and systems, and the Blue Economy considers open-source collaboration and innovation.

CE can be defined as “a regenerative system in which resource input and waste, emissions, and energy leakage are minimized by slowing, closing, and narrowing material and energy loops” (Geissdoerfer et al., 2017, p. 759). The main vision of the CE emphasizes the minimization of waste generation by enabling the circular use of materials and other resources in order to reduce the environmental footprint from resource extraction and break current destructive patterns of consumption and production (MacArthur, 2013, Geissdoerfer et al., 2017). Currently, fully circular product systems do not exist at scale, with the exception of small-scale pilots for regional industrial symbiosis or partial products internal to a single firm (Hofstetter et al., 2021).

CE often requires a socio-technical transition as it involves interactions between individual and collective agents mediated by technology and requires significant behavioral changes from individual consumers, businesses, and governments. This transition requires a strong focus on material flows, reverse supply chains, and material recovery strategies. The strong focus of CE on material flows rather than energy is justified because many materials have a practical limitation on supply, while non-fossil energy does not. The main focus within the CE is to “close the loops” by redesigning products to extend their lifecycles, as well as

recycling, reusing, and remanufacturing products and their components and minimizing the amount of waste produced within production systems. Many small material loops throughout supply chains are seen as a way to reduce environmental impact because they require less processing of materials (Stahel, 2010). However, redesigning the reverse supply chain toward accelerated recycling and increased material recovery requires digital technologies that can collect, sort, and analyze information on the location and conditions of products and their constituent parts (Liu et al., 2022). Moreover, making effective end-of-lifecycle decisions about reusing components and materials involves the availability of real-time data on their status, maintenance, damage, and material compositions (Laskurain-Iturbe et al., 2021). Current literature focuses largely on using digital technologies to inform decisions regarding the repurposing, remanufacturing, refurbishing, reuse, and repair of products by collecting and sharing information between multiple stakeholders (Awan, Sroufe, & Shahbaz, 2021). Furthermore, as supply chains have become increasingly global and complex (Kim & Davis, 2016), the adoption of CE practices also needs to cross regulatory boundaries, as input is needed from upstream supply chain partners and outputs can be distributed to users all around the world.

One additional challenge relates to moving from transparency and availability of data toward transforming that information into sustainability outputs. Transparency in itself does not lead to CE practices, but using the knowledge resulting from such transparency may lead to different trajectories and tactics to achieve them (Ki, Chong, & Ha-Brookshire, 2020).

DPPs are envisioned as digital information tools holding product information pertaining to their entire lifecycle, from the extraction of raw materials and the manufacturing phases to shipping, distribution, and use until their end of life. Currently, several information tools exist that are used to certify certain properties and qualities of products, services, or processes. Similarly, Adisorn, Tholen, and Götz (2021) detail the characteristics of other existing information tools used in the areas of materials and energy efficiency and also compare them to DPPs. From these comparisons, a straightforward deduction is made that DPPs will be applicable to a highly diverse set of application areas and will address corresponding value chains end-to-end.

3.2 Implementation Challenges

Recent advancements in digital technologies provide tools and methods for collecting and processing data from physical systems, production processes, and product usage. This data can be collected and processed continually, in near-real time, and at scale, resulting in data sets with enormous potential for identifying inefficiencies (Kristoffersen, Blomsma, Mikalef, & Li, 2020). Consequently, novel data-driven design methods and tools for circular systems and processes that enable continual and fine-grained evaluation of their circular efficiency throughout the lifecycle management of a product or service can be developed.

Furthermore, the use of DPPs will be agile and dynamic, allowing multiple actors to continually update and augment the set of information carried by a DPP. The carried information will be granular enough to describe individual items (rather than product types), while also being structured and interoperable so that knowledge can be extracted regarding different scales, from the lifecycle of individual items to the cross-sectoral interdependencies between different value chains. This power of DPPs stems from the use of emerging ICT (AI, the Internet of Things, and others) that enables the continual collection and processing of highly voluminous and multi-modal data.

Çetin et al. (2022) propose a framework for a digital circular built environment that is based on the preceding (to DPP) concept of material passports. By using the construction sector as an example, they identify that data sharing and monitoring of CE progress are the main challenges to implementing CE. In particular, implementing looping actions (i.e., closing the loop between waste and resources) and measuring progress toward circularity necessitate the collection, storage, and sharing of relevant data among actors throughout the product lifecycle using digital technologies that facilitate collaboration and trust. In this context, the Internet of Things (IoT), Big Data Analytics, Blockchain,

and Digital Twins are regarded as key enabling technologies.

Similarly, in Gligoric et al. (2019), authors consider product passports and data exchange as key facilitators for reaching the next stage of a Circular Economy. They also identify the Internet of Things and SmartTags based on printed sensors (i.e., using functional ink) as key technologies for collecting, sensing, and reading parameters from the environment, as well as tracking the lifecycle of a product. Their approach moves beyond currently established practices where QR codes and data matrices are used at the Stock Keeping Unit (SKU) level. Instead, authors envision using IoT and SmartTags to identify specific components, not just the integrated product, and to continually collect data throughout the lifecycle of the product. Such practices will not only facilitate the tracking of products, materials, and resources. However, it will also enable novel business models in line with the principles outlined by the major CE schools of thought (e.g., the Blue Economy).

While emerging digital technologies are key enablers for collecting and processing product-related data and information, their use extends beyond and covers equally important aspects of data transparency and trustworthiness. Berg et al. (2022) consider the plastics value chain and address the challenge of information asymmetry and intransparency in the market for recycled plastics (recyclates). In particular, they highlight the role of the knowledge gap between plastic recyclers and producers of plastic products (manufacturers) in underperforming markets and lower amounts of high-value recycling. Toward bridging this gap, the authors consider using product passports implemented as decentralized identifiers and verifiable credentials to overcome information deficits and information asymmetry in the circular plastics economy. They propose using a decentralized public key infrastructure (DPKI), which allows the creation of digital identities for companies and products and the exchange of trustworthy and digital product passport data among all players in the plastics industry. Key enabling technologies include Self-Sovereign Identities (SSI), Decentralized Identifiers (DIDs), and Verifiable Credentials (VCs).

Equally important to the technologies enabling the implementation of DPPs is the information that will be stored in and carried by the DPPs. Berger et al. (2022) claim that DPPs can help value chain stakeholders identify sustainable loop-closing pathways, thus facilitating the transition to a CE. In particular, DPPs can function as unique identifiers of the corresponding physical products by containing specific product- or material-related data and gathering real-time data over the entire life cycle of a product. Berger et al. (2022) consider the use case of electric vehicle batteries (EVB) and present a preliminary conceptual DPP information model based on a systematic literature review that also considered regional initiatives from the European Commission. The model provisions storing EVB-related information on the DPP pertain not only to the chemical and physical characteristics of the product but also to its sustainability and circular characteristics, such as the length and locality of the product value chain and the involved actors throughout its lifecycle.

3.3 Digital technologies enabling digital product passports

The implementation of DPPs and their leverage to facilitate the transition to more sustainable, and eventually circular, value chains is made possible by recently introduced and emerging digital technologies. Pagoropoulos et al. (2017) provide a systematic literature review in an effort to evaluate the application of key digital technologies in a CE. Moving beyond this scope, in the following, we provide an outline of enabling Digital Technologies for the DPP landscape, presented in three distinct tiers according to the specific functionality they enable: i) data collection; ii) data curation, processing, and sharing; iii) data use and exploitation.

The primary aim of DPPs is to hold data regarding the physical, chemical, structural, or other characteristic properties of a product. Such data is to be provided during the production phase by the manufacturer of the product but also needs to be collected throughout its lifecycle. This is because, depending on the use case, the characteristic properties of a product may be affected differently according to how it is being used, its operational environment, etc. This product data collection can occur either asynchronously at specified product

lifecycle milestones or, ideally, in an automated and continual way.

Printed sensors and tags are devices manufactured using printing methods that can monitor a physical process and/or emit data, typically a few bits. Benefits of using printing technologies include the possibility to use flexible substrates, resulting in thin and light-weight devices at a very low cost, and using simpler infrastructure than, for example, the semiconductor industry (Gligoric et al., 2019), which can also be more sustainable; the authors in Maddipatla et al. (2020) provide a comprehensive review of state-of-the-art manufacturing techniques. The small and flexible form factor, along with the low production cost, allows the integration of printed sensors in several types of products in large numbers, thus enabling automated and continuous data collection from individual products en masse. The most intensively evolving types of printed sensors include biosensors, capacitive sensors, piezoresistive sensors, piezoelectric sensors, photodetectors, temperature sensors, humidity sensors, and gas sensors (IDTechEx, 2017).

Distributed and decentralized identifiers (DIDs) enable the unique identification of products at the item level. Contrary to currently established methods (such as printed QR codes) that enable the identification of the type of product and brand, DIDs enable the identification of the specific item, thus allowing the collection of data and tracking the item throughout its lifecycle, a key requirement of DPPs. On the other hand, self-sovereign identities (SSIs) enable individual actors to claim and prove their own identities without the need for a centralized trusted party. Verifiable Credentials (VCs) are a form of machine-readable credentials that are cryptographically secure and privacy-preserving. The combined use of SSIs and VCs enables different actors across the product value chain to access or add data to the DPP of a product throughout its lifecycle. The distributed and decentralized nature of the aforementioned technologies greatly facilitates the adoption and use of DPPs by highly diverse and large groups of product stakeholders that would otherwise be very challenging to manage with centralized approaches. However, a currently existing disadvantage is the lack of universally adopted standards, which hinders the onboarding of the technologies. Nevertheless, steps are being taken in this direction, such as the approval by the W3C of the W3C Decentralized Identifiers 1.0 (W3C, 2021) as a new web standard in July 2022 (the first identifier approved as a W3C standard since the URL).

The Internet of Things (IoT) is a technological paradigm that enables the massive and seamless integration and interconnection of machines and devices with the Internet and the use of Internet services. To this end, the IoT encompasses a wide range of technologies, forming a rich and diverse technological system that enables the continual collection of dense data in the space and time domains. From recent advances in low-power and batteryless electronics, energy management (including wireless power transfer), efficient low-power wireless communications for local area networks (IEEE 802.15.4, XBee, Bluetooth Low Energy), and wide area networks (LoRaWAN in the unlicensed spectrum and 5G/NB-IoT in the licensed spectrum), to IoT service provisioning and composition, and innovative IoT-enabled business models. This rich technological system underpins broader socio-economic paradigms, one of which is data-driven or digital CE (Angelopoulos et al., 2019); i.e., a Circular Economy that can track and optimize the production and consumption of services and products throughout their lifecycles at great scale by leveraging digital technologies.

3.4 Data amalgamation, processing, and sharing with digital product passports

DPPs are aimed at collecting and holding data pertaining to the entire lifecycle of individual items and products. Holding, processing, and sharing this vast volume of fine-grained and high-fidelity data necessitates the use of innovative digital technologies that, in several cases, go far beyond conventional approaches.

The first technology is Cloud Computing (CC), which enables the elastic and on-demand availability of computing resources (e.g., computing power and storage space) in a way that relevant technical challenges are hidden from the user. Its proliferation in the early 2000s underpinned the rise of new market sectors (such as e-commerce) by greatly reducing costs and dis-associating the physical and cyber spaces (e.g., in terms of accessing data and e-services). However, the

continuously growing demand for computer resources and reduced latency in accessing them provide motivation for more agile and decentralized approaches. Multi-access Edge Computing (MEC) and the closely related Fog Computing paradigms enable the provision of computing resources at the edge of a network, close to the end users. This approach assumes distributed network architectures that contradict the highly centralized approaches in CC. Making computing resources available at the network edge significantly reduces the distance between running services and their consumers, leading to significantly reduced transfer and processing times. At the same time, data can be processed close to where and when they are generated, ensuring that they are timely and relevant for the end user (consider data referring to current environmental conditions). In addition to enhancing security and privacy, these decentralized and distributed architectures allow for the sharing of processed data rather than actual raw data with remote systems. In the context of DPPs, modern Cloud Computing (e.g., using microservices or serverless approaches) and MEC architectures enable the development of digital infrastructures that can support the great volume of transactions and data pertaining to (potentially) myriads of items and actors. As an example, consider a DPP infrastructure using Distributed Ledger Technologies to register data. A MEC architecture would allow transactions to occur on the edge of the network, in physical proximity to the actual item or actor, supporting high throughput rates and low latency.

Secondly, Data Analytics (DA), Machine Learning (ML), and Artificial Intelligence (AI) enable the efficient curation and processing of data to identify underlying patterns and elicit information and knowledge from it. Corresponding methods have been developed for various types of data, from large-volume data sets to continuous streams of data and from highly structured data to ad-hoc, unstructured data. Underpinned by advancements in the aforementioned IoT and MEC technologies, AI models can now be natively deployed on machines and embedded devices and operated without the need for continuous connection to the Internet. This way, new pathways for product data collection are revealed that are not dependent on the presence of other ICT infrastructure.

Finally, Distributed Ledger Technologies (DLT), including Blockchain, provide the means for maintaining distributed and structured collections of data (data ledgers). With the use of cryptographic methods, modern DLTs and Blockchains can provide guarantees regarding the timeliness and veracity of data, the attribution of actions on the ledger to actors, as well as technical means for maintaining the ledger synchronized across multiple sites, actors, and institutions. This is achieved using consensus mechanisms that operate over peer-to-peer networks without the need for a centralized managing authority (although, in specific cases, some level of control can exist, e.g., in permissioned Blockchains). These characteristics make DLTs and Blockchain promising technologies for enabling DPPs, as they provide the means both for maintaining and sharing structured data while preserving trust and privacy. In this regard, these technologies also promote circularity in broader contexts, such as Smart Cities (Damianou et al., 2019).

3.5 Data exploitation and use with digital product passports

Data collected and shared using the aforementioned technologies can be leveraged to support a broader set of functionalities such as designing and improving product design processes, informing decision-making for increasing the efficiency of value chains, and interconnecting disjointed value chains with the aim of closing loops. DPPs can be instrumental in facilitating such data exploitation at scale.

Digital Twins (DT) can be used to monitor, reflect, and potentially influence the current state of their physical counterparts. DT refers to virtual representations of physical objects, products, or systems built using Digital Technologies. A DT can vary in terms of complexity as well as its intended use. In its simplest form, a DT serves as a virtual model of an object, product, or system to represent its characteristic properties. The model can then be used in order to evaluate modifications and improvements through simulations before those are applied to the physical counterpart. At the next level of complexity, a DT serves as the digital shadow of its physical counterpart. In this case, the properties and the environment of the modeled subject are

dynamically monitored (e.g., through smart tags and sensors) and reflected on the virtual model. At the highest level of complexity, the DT serves as a complementary digital component of a cyber-physical object, product, or service. It has the ability not only to monitor and reflect the current state of the physical counterpart but also to process this data and act upon it, thus forming an integral part of its operation and behavior.

Finally, marketplaces and trading platforms for physical and digital assets are virtual spaces and online services that enable the discovery and exchange of assets by leveraging corresponding digital data. With the ongoing digitization of products and their value chains, marketplaces exploit relevant data and facilitate the transition to the Circular Economy by helping close production and consumption loops. Indicative examples are the AssetHUB (https://www.asset-hub.co.uk/) in the UK, where providers of digital infrastructure make their assets available on the marketplace to be discovered by potential users, and the SyncOnSet Asset Hub (https://www.synconset.com/home/asset-hub/), where production companies can track and manage entertainment equipment. Marketplaces and trading platforms can address the need to discover and identify available assets at scale (e.g., in a Smart City), provided that the available data are structured and open. DPPs will be well-suited to address these needs at the level of individual products.

4. Competitive Analysis

In the previous section, we provided an outline of enabling Digital Technologies for DPPs. In this section, we move beyond the technical context of DPP implementation and provide a transdisciplinary analysis of their possible implications. In particular, we take a broader look at the operational environment of DPPs considering the perspectives of economic competitiveness, geopolitical relationships, and globalization processes, including implications for global supply chains.

Economic principles suggest that without clear, reliable incentives, firms will not adopt circular behavior (Domenech & Bahn-Walkowiak, 2019). A major legislative failure globally has been the lack of true pricing, often termed “polluter pays” regulation (Green, 2021). This means that damage to public property through pollution or resource depletion is not factored into financial decision-making, and firms have little incentive to change. In fact, we can go further and say that this failure prohibits firms from adopting circular business practices, as they would be unable to match the cost structure of their unsustainable competitors. For industries and whole economies to truly embrace the CE, there needs to be a positive business case for it (Sarja, Onkila, & Mäkelä, 2021), including initiatives that support it, such as DPPs.

Socially, in some contexts, there is a growing consensus on sustainability as a legitimate basis for business practice. For example, many investment brokers are challenging firms seeking capital to improve their sustainability credentials (Weston & Nnadi, 2021). However, much of the world’s population strives to attain a modern Western lifestyle with its high material use and emissions. Accordingly, for DPPs to contribute in any significant way to meeting climate goals, there needs to be a broad, unified implementation. This includes the viewpoints of both the firm and the consumer, so that all stakeholders understand how they can benefit from DPPs and use the data to minimize their environmental impact while remaining economically viable.

At the political level, control of raw materials is increasingly becoming a global issue as many developed countries outsource material extraction, mostly to developing countries, which suffer the environmental and social damage it usually brings. Outsourcing is done because developed countries usually want to avoid the environmental and social damage that resource extraction brings or because they do not have access to these resources themselves. Poorer countries that suffer the worst effects of climate change have been pressing for financial help from richer countries at each United Nations Climate Change Conference, with limited success. The implementation of regulations on DPPs is likely to add pressure on firms from developing countries, for example, by requiring them to invest in costly digital infrastructure to provide the high-quality data needed for the DPPs to work. Access to digital platforms cannot be evaluated uniformly across different countries and regions (Tiwari & Srivastava, 2020). For example, based on household surveys and additional

modeling tools, the International Telecommunication Union (ITU) estimates that, globally, 76% of individuals in urban areas use the internet, compared to 39% in rural areas (ITU, 2021). In the Indian context, for example, there is a disparity between urban and rural areas in terms of physical infrastructure for digital operations, such as data centers, telecom infrastructure, and computer access. Therefore, a smart transition to CE will prove to be challenging in regions where digitalization is lagging, and policymakers need to be aware that DPPs have the potential to exacerbate economic inequality.

Uneven access to digital platforms and physical digital infrastructure is a result of ongoing globalization processes. Despite globalization, fuelled by digitalization, making the world appear flat (Friedman, 2005), economic activity has never been more geographically concentrated, meaning that economic activity, including innovation as a result of digitization, is still highly location-dependent (Florida, 2005). The development of digital technologies like DPPs is imperative to CE as they support and enable collaboration between partners (Chauhan et al., 2021). Digital platforms potentially solve information asymmetries, enhance effective information sharing, and reduce transaction costs (Wilts & Berg, 2018). However, a smart transition in CE through digitalization has inherent geographical limitations, and there is a distinct possibility that DPPs will intensify the geographic concentration of economic activity and innovation in CE.

The geographical and inter-regional implications of DPP are significant. In a worst-case yet not wholly unlikely scenario, these EU-centric DPPs will serve as a barrier for suppliers in developing countries where the EU sets production standards globally, insisting on a level of digitalization that is, for many countries, unattainable.

4.1 Challenges and opportunities

From a supply chain perspective, DPPs seemingly present significant opportunities for industrial ecosystems to become more transparent and resilient and increase the accountability of global producers. Industrial ecosystems are multi-tiered production systems involving heterogeneous agents operating in sectoral value chains and contributing to the capability domains of the ecosystem (and its participants) with closely complementary but dissimilar sets of resources and capabilities. The geographical boundaries of the industrial ecosystem are shaped by the evolving interdependencies linking organizations within the ecosystem and by the new linkages consolidating beyond that. Thus, the industrial ecosystem is a structured production space centered mainly on its productive organizations, as well as other institutions, intermediaries and demand-side actors, purposefully involved in co-value creation processes along various types of diversification and innovative industrial renewal trajectories (Andreoni, 2018, 10). As such, an industrial ecosystem consists of multiple value chains, or value networks, and in addition, value chains may stretch across various industrial ecosystems.

Yet, implementing DPPs presents a challenge to industrial ecosystems because of their highly complex, dynamic, and geographically dispersed supply chains. In this context, most firms do not have full visibility and transparency over their supply chains, including the supplier networks and origins of products (Kim & Davis, 2016). Even when there is full visibility of the supply chain nodes and linkages, the quality, reliability, and accuracy of the information coming from the different nodes of the supply chain is limited because of diversity in monitoring practices, suppliers' approaches to deceive the systems in place, and the difficulty with measuring sustainability impacts beyond the individual supply chain node level (Gualandris et al., 2015).

Traditional supply chains are largely linear, with limited attention to reverse flows where materials and products are brought back into the system. Moreover, these global supply chains are highly unbalanced compared to the natural ecosystems of plants and animals, where scavengers and decomposers play as important a role as producers and consumers (Tate et al., 2019). The Extended Producer Responsibility (EPR) models show that new types of ecosystem actors may be needed to manage recycling and waste collection on behalf of multiple producers. Yet, this can increase industrial ecosystem complexity because multiple such intermediaries might be needed for different types

of products and countries (Kunz et al., 2018). The implementation of DPP presents major opportunities to address these challenges and strengthen the focus on reverse flows and a more balanced distribution of roles and functions across the supply chains, enabling the production and reuse, recycling, and remanufacturing of products.

The key value of CE revolves around the reduction of extractive practices, which account for a large environmental footprint while maintaining economic competitiveness. However, scholars are increasingly pointing out the unintended consequences of some seemingly beneficial steps. In this part of the transdisciplinary analysis, we explore these unintended consequences and describe the need for holistic orchestration of industrial ecosystems as they transition toward the CE through the use of DPPs.

While many firms communicate a strong emphasis on sustainable practices, most solutions adopted in practice do not fully address the major shortcomings of the current industrial system and still largely focus on the use of virgin materials, fossil fuels, polluting technologies, short lifecycles, a lack of repair and upgrade solutions, complex and wasteful supply and distribution networks, and extensive marketing-driven overconsumption (Bocken & Short, 2021). Nevertheless, some regulatory solutions, such as Extended Producer Responsibility (EPR), are beginning to have some positive effects by forcing producers to take responsibility and bear the costs of waste resulting from the sale of their products. Key learnings from the implementation of EPR models emphasize the need for a collective approach to waste collection and recycling, harmonized legislation between different legislative areas, the development of a coordinating framework that can enable the proper enforcement of recycling standards, and the role of orchestrators such as Producer Responsibility Organizations (Kunz et al., 2018). The role of such orchestrators is also outlined by CE studies that advocate for independent intermediaries who can orchestrate and coordinate the collective efforts needed to implement CE practices across supply chains, as the emergence of circularity brokers in the food supply chain illustrates (Ciulli et al., 2020). The existence of such orchestrators requires new business models to provide economically viable ways to recover materials and reduce the consumption of virgin materials while being competitively viable (Lüdeke-Freund et al., 2019). Beyond this, consumers also have a large responsibility and should be included in the orchestration process. There is a need for clear regulatory incentives (e.g. producer responsibility) and a shift in social norms regarding pro-environmental behavior (e.g. moving away from single use plastics, flight shame) for CE adoption by both consumers and businesses. Research in this area suggests that pro-environmental norms can emerge and evolve as a result of individuals aligning their behavior with societal expectations (Young, 2015), whereby pro-environmental norms can be effective in shaping behavior by fostering a collective sense of responsibility and encouraging individuals to conform to environmentally friendly practices (Nyborg & Rege, 2003).

To advance the transition to the CE, there is a need for collaborative, cross-industry, multi-level efforts centered around joint planning and coordination of reverse material flows (Boldrini & Antheaume, 2021). Many successful CE initiatives are characterized by their relational nature; they are based on partnerships and collaborations between manufacturers, service providers, and non-economic actors, such as NGOs or governmental authorities, who are critical in raising awareness among relevant firms, consumers, and society at large (Lüdeke-Freund et al., 2019). Moreover, some recent studies suggest that while data collection within organizations is frequently used to increase energy and resource consumption efficiencies, it is the data collection from multiple external partners that can enable CE activities such as end-of-life activities, collaborative cradle-to-cradle design, and industrial symbiosis (Liu et al., 2022). Particularly, the orchestration of access to this type of cross-firm data is difficult, as many firms fear data security breaches or the loss of commercially sensitive information. These information vulnerabilities and hesitations from firms to share their data can be addressed by policies and regulations from the government (Chauhan et al., 2022). In this context, there is a need for system-wide orchestration of data access and usage, and therefore actors suited to this role are needed.

One particular form of collaborative efforts toward CE involves industrial symbiosis practices, in which traditionally separate industries are engaged in a collective approach to competitive advantage involving physical exchange of materials, energy, water, and by-products (Chertow, 2000): thus, a network in which waste from one industry is used as a resource for another industry. . Key components to industrial symbiosis are collaboration between industries and the synergistic possibilities that are offered by geographic proximity (Chertow, 2000). Industrial symbiosis at a large scale can enable material recovery with significant reductions in the system's environmental footprint. Enabling cross-industry material flows can significantly reduce waste by increasing the reuse of components and materials. While industrial symbiosis is a promising strategy, there is still enormous untapped potential in connecting disparate supply chains in new forms of industrial ecosystems (Neves et al., 2019). One of the main reasons for the unfulfilled potential of industrial symbiosis is the lack of integration and information sharing between different industries and the lack of data on supply and demand between different industries and companies, which is amplified by uncertainty surrounding quality and coordination issues (Ashton, 2021).

The orchestration of business strategy across networks, such as supply chains, is a process in which different stakeholder incentives are made explicit and aligned in such a way that a governance structure emerges for the benefit of the network as a whole, not just one dominant firm (Nambisan and Sawhney, 2011, Parida et al., 2019). This is brought about by knowledge mobility, innovation appropriability, and network stability (Dhanaraj & Parkhe, 2006).

4.2 Unintended consequences of digital product passports adoption

The implementation of DPP may give rise to unintended negative consequences, some of which could potentially be mitigated through careful orchestration of industrial ecosystems. Nonetheless, despite effective orchestration, some unintended effects may still persist, and an increasing number of studies have shown that linking the supply and demand of secondary materials does not directly reduce environmental impact, and there is a need for a more holistic view of secondary production and its interlinkages with demand and other economic factors (Zink & Geyer, 2017). The term Circular Economy Rebounds (CER) has been proposed to account for these secondary, unintended effects of CE (Zink & Geyer, 2017). CER incorporates indicators beyond energy use and emissions to add a wider range of other environmental implications, with possibilities to broaden the concept to include economic and behavioral feedback loops (Font Vivanco et al., 2016). CER can present itself in three main formats: increased demand for goods and services created by net savings; the ability to substitute primary production; and improved efficiency leading to increased usage of the same product, service, or energy (Warmington-Lundström & Laurenti, 2020). While there are many challenges with conceptualizing and operationalizing CER related to the boundaries of the concept, measurement issues, and domain-specific interpretations, there is agreement that a holistic approach is needed to assess the multifaceted impact of CE practices.

The last mentioned CER format can arguably be extended to the energy used for materials and products to cover the distance between industries. One of the aims of implementing DPPs is to enable cross-industry material flows in which waste from one industry is made available as a resource for any other industry. However, in connecting material flows, geographical distance and transport emissions play a significant role, which is often neglected in policy discussions. In order to close material loops within and between industrial ecosystems in an efficient and sustainable manner, physical distance should not be neglected. Ultimately, the CE is proposed as a means to realize efficient use of materials and CO2 emission reduction. However, creating a global network of material flows is not necessarily logical for specific products and materials. For instance, the global transportation of large quantities of heavy materials, like recycled iron, might result in vast quantities of emissions, which goes against one of the main goals of the transition to the CE. Despite the environmental impact being smaller for lighter products and materials, it can be argued that DPPs should integrate transportation emissions in order to optimize material flows within geographical contexts, and orchestration efforts can design

relevant regional clusters of mutually beneficial production processes.

One unintended consequence of the EU-imposed data sharing for enabling DPP is the heightened openness and distribution of data required. Compared to the situation without a DPP, where data sharing may be more limited, the open nature of data in DPP poses a potential risk for firms. The increased accessibility and availability of data through DPP could lead to concerns over intellectual property protection and potential competition risks, as firms might worry that their proprietary information and trade secrets could be more easily accessed and utilized by competitors or unauthorized parties, compromising their market advantage and potentially undermining their business interests. This perceived risk of data openness within the DPP framework may create apprehension among firms and impact their willingness to participate fully in the data space.

An additional difficulty is that different geopolitical regions adhere to different approaches to sustainability in the production and use of products. The EU, through its Green Deal, is developing far-reaching policy to force firms to comply with regulations that could help the region meet its emission reduction goals, including the Carbon Border Adjustment Mechanism due to come into effect in 2026 and the proposal for DPPs themselves, which are not a part of other regions' policy measures. The USA's patchwork of local and state legislation and its market-led approach to sustainability and the circular economy have resulted in a less regulated environment where consumer choice, typically motivated by price considerations, will largely determine the extent to which national climate goals are met. The increasing polarization of opinion relating to climate policy between the Democratic and Republican parties means that opportunities for bipartisan policy innovation are increasingly unlikely. China, the world's largest emitter of greenhouse gasses, has a mixed approach to climate policy, as it has invested heavily to become a global frontrunner in solar and wind power, as well as in electric vehicles, but, at the same time, it also invests heavily in highly polluting coal-fired energy production and continues to finance a significant expansion of coal-based energy capacity in both domestic and foreign markets (Sandalow, 2020). For DPPs to truly impact the global sustainability crisis, they must be acceptable and interoperable with all major global regions. This will require a long process of negotiation, and the EU's step toward a regional DPP regulation may thus be seen as one step in this direction.

Summarizing the previous section, Fig. 2 shows how the transdisciplinary analysis synthesizes current insights from the literature on CE and DPP to provide a state-of-the-art summary (1st order themes) on the socio-technical transition to the CE, leading to structured insights (2nd order and emerging themes). Fig. 2 also contains several insights specifically emerging from the experts discussion - a brief explanation of those can be found in Appendix 1. In the following section, these 2nd order themes form the basis of eight guiding principles for a framework for orchestrating the implementation of DPP aimed to achieve a CE.

5. Product Design

Emerging from the transdisciplinary analysis described in the previous section, we distinguish between eight key steps or guiding principles in the DPP orchestration process throughout industrial ecosystems, as depicted in Fig. 3, whereby certain firms, such as hub firms, platform firms, or innovation intermediaries, lead collaborative network activities to ensure value creation and appropriation across industrial ecosystems without the benefit of hierarchical authority (Dhanaraj & Parkhe, 2006). The orchestration process guiding principles? begin with (1) the requirements analysis of regulations, such as the upcoming EU regulation on DPP, industry regulation, or firms' self-regulation. Using these requirements, the next step is (2) the design of DPPs and their governance, where good orchestration prevents the concentration of power that would lead to a "winner takes all" scenario and, instead, adheres to best practices in open infrastructures and decentralized data spaces that are modular, interoperable, transparent, and ensure data sovereignty (Braud et al., 2021, Beverungen et al., 2022). Orchestration of (3) data technologies requires that beneficial choices are made with respect to the standardization policies to adhere to, the types of data to be included in the DPP, mechanisms for their verification and

validation, knowledge engineering through AI, and more.

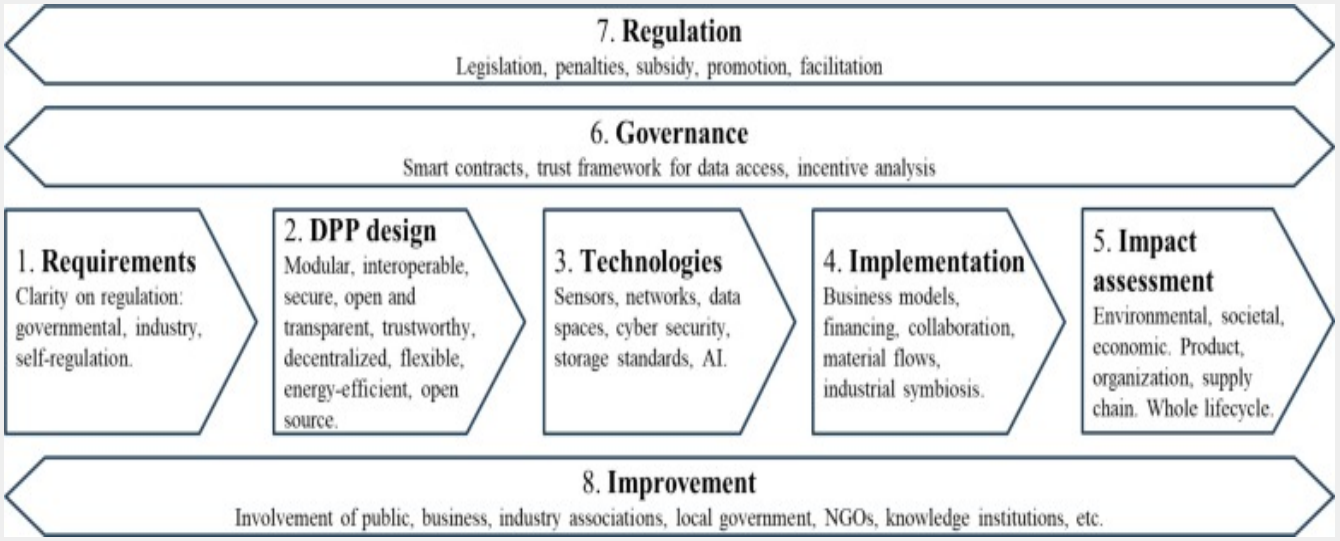

Fig. 3. A framework for the orchestration process in the design and implementation of Digital Product Passports throughout industrial ecosystems.

A crucial part of the orchestration process is to align stakeholder requirements in (4) a governance mechanism that includes an analysis of participant incentives, a trust framework setting out which parties provide access to their data for which purposes and under what conditions, as well as contractual agreements. (5) Implementation in practice requires more than putting the technologies and governance mechanisms into operation, as it impacts the business models of firms throughout the industrial ecosystem, including their value propositions, cost structures, and revenue models, and may even change the customers that firms supply to. As the DPPs lead to efficiencies and reduce the limiting effects of supply chain bottlenecks, particularly through AI-based optimization algorithms, firms may develop new material flow pathways, and they may find their business practices changing accordingly.

The DPP orchestration process includes the involvement of (6) regulatory bodies as the DPPs are used to assess compliance with regulations on material flows, energy emissions, waste management, including recycling, etc. Governmental regulation of minimum standards may be augmented by industry-wide agreements or individual firms' self-regulation, such as adherence to the principles of the circular economy by maintaining the highest value for components and materials and decoupling products' manufacture and use from their environmental impact. Orchestration requires insight into the effects of DPPs through (7) impact assessment to measure the holistic effects on social, environmental, and economic indicators. This will consider not just the direct effects made visible through a product's DPP but also the indirect and rebound effects. This poses a significant challenge for orchestrators, as such indirect effects may be difficult to identify or measure. The final orchestration step is (8) the continual improvement of the DPPs and their governance through close cooperation with multiple stakeholders, including public bodies, firms, industry associations, local governments, consumer groups, knowledge institutes, and others.

These eight key steps for orchestrating DPPs have been distilled through a process of interdisciplinary dialogue and leveraging relevant insights from the numerous streams of literature that address this topic..

Building upon the trans-disciplinary analysis presented above, in this section, we propose a set of guiding principles for designing and implementing a DPP from the perspective of managers in firms that are involved in producing products. At the same time, the guiding principles provide a theoretical basis for scholars on the implementation of DPP toward a CE, as multiple scientific and societal views are recognized and condensed (Brennan et al., 2021).

Specify the requirements for the DPP at the system level, making both its objectives and the reasoning behind them clear to all stakeholders.

A DPP is a collaborative endeavor that will only lead to sustainability benefits if all relevant parties work together. A necessary first requirement here is that each firm understands what is required of them, how that fits into the wider product production process, and the basis for these requirements. Indicatively, with regard to the use of ICT, this need for clarity pertains to understanding the functional requirements of a system; e.g., what types of data need to be collected and what processes need to be monitored. If any lack of clarity is allowed to cloud interpretations, then members of the industrial ecosystem may take steps to the detriment of the DPP, such as withholding important information. For example, a small metalworking factory may already use offcuts of high-grade steel for purposes where low-grade steel would be sufficient. This firm needs to understand the system-level requirement of maintaining the highest possible material value. Clarity on requirements is therefore a necessary but insufficient component of the DPP design and implementation process.

5.1 DPP design principle

Use data spaces to create decentralized, open infrastructures that are modular, interoperable, transparent (open source), and ensure data sovereignty and security.

The implementation of DPPs needs to follow a design that allows for their widespread use across multiple sectors, prevents power centralization, and maximizes their impact. In this context, the implementation of DPPs needs to assume a decentralized architecture and enable the self-sovereign identification of actors to provide and access data without the need for intermediaries. This is a significant challenge in the current digital landscape, where a small number of large tech firms provide highly competitive cloud services with a centralized architecture. DPPs also need to employ open ontologies and standardize data formats to make stored data and information discoverable and open. Open and platform-agnostic approaches to implementing DPP interfaces will ensure interoperability between the systems of different actors and make data security transparent, thereby facilitating the widespread and scalable adoption of DPPs.

5.2 DPP technology principle

Collaboratively decide which democratizing digital technologies to use that are readily available to and implementable by all parties across the industrial ecosystem.

For a fully functioning DPP that has a meaningful impact at the system level, the digital maturity of all parties needs to be brought up to a suitable level. For this to happen without having detrimental effects on those parties situated in contexts with less advanced digital infrastructure, there needs to be a collaborative decision-making process with respect to technology choices. This pertains to the technical requirements of DPP infrastructure; i.e., which technologies are used and how (note the difference to functional requirements mentioned in section 4.1 DPP Requirement Principle). For example, suppliers in developing countries may be willing to commit to one specific DPP implementation as long as it aligns with alternatives for other customers, thus reducing any fear of lock-in. Adhering to this DPP technology principle can form an inclusive boost to the willingness of all parties to commit to the DPP, rather than an exclusive barrier to participation. For advanced AI technologies, for example, it is the responsibility of the parties in more developed regions to support implementation in less developed regions.

6. Marketing Plan

Define business models that fully align with the objectives and workings of the DPP, as verifiable improvements to the efficiency of material flows will result in a commercial advantage.

Business models specify the strategy of a firm's product development, taking into account both upstream supplier concerns and downstream customer requirements, and they lay out what forms of value are created and captured. As the DPP will have potentially far-reaching consequences for many firms in an industrial ecosystem, its implementation requires all participants to revisit their business models and realign them with the objectives and workings of the DPP. Some firms' business models may change dramatically, requiring forward-looking leadership. Particularly the firms

that provide virgin raw materials, such as mining exploitation companies, face the challenge of redefining their value creation by pursuing alternative sourcing options, or they will be excluded. Any waste produced during the production process may be commercialized, such as through local industrial symbiosis, where new partners may be sought beyond the traditional supply chain. For example, experiments are underway in a Swedish steel factory, to provide nitrogen-rich waste gases for firms involved in fertilizer production. Best practice in the CE prescribes maintaining the highest value for materials. This means that a business model that includes refurbishing components has a higher value than one that includes recycling raw materials.

For a production system as a whole to show a positive sustainability impact, the DPP needs to be clear about all knock-on or rebound effects, as this will enable sustainability innovations to be commercially viable and, by extension, partial solutions to be evaluated appropriately. For example, e-scooters have been hailed as being environmentally friendly because a single vehicle is used by multiple people instead of each person buying their own. However, in practice, e-scooter trips in congested cities often replace trips that would otherwise have taken place by bicycle, public transport, or on foot. The environmental cost of collecting and distributing e-scooters is far higher than that of charging their batteries. Similarly, lifecycle analysis techniques must be expanded to account for the complexities of closing material flow loops, such as novel symbiotic relationships found across industrial ecosystems. Indeed, a full range of stakeholders need to be included in determining the scope of impact assessment, including citizens, businesses and public organizations, as meaningful impact can mean different things to different stakeholders.

6.1 Governance

Develop a collaborative trust framework setting out which parties provide access to their data to which users, for what purposes, and under what conditions, codified into contractual agreements.

A DPP will provide detailed insight into material flows and related production processes and may be seen as a commercial risk to some parties that have justified concerns about who gains access to their data and the potential for competitive misuse of that data. Through a collaborative trust framework, all participant incentives, restrictions, and obligations are laid out, ensuring—alongside the technical design—that the DPP does not form a commercial risk and that power in the industrial ecosystem does not reside with a single DPP-owner. In fact, with a strong trust framework in which all parties have an appropriate stake and clear rights, the DPP will become a strong incentive for system-wide innovation toward sustainable production practices.

6.2 Regulation

Create relationships with regulators to promote the need for support in developing fair and meaningful DPPs.

Firms are not passive observers in the development of legislation and other regulations but can engage in open, transparent discussions with regulators and policymakers in order to explain the implications of regulations and the implications of differences in regulations between regions or territories. As the European Union appears to be taking the lead in enforcing the use of DPP, it is logical for firms situated outside of the EU but involved in products for sale within the EU to persuade their regulators to base their legislation on similar sustainability objectives. This will result in penalties or subsidies that incentivize firms to work with DPPs. Additionally, leading firms can assist regulators in developing appropriate promotion and facilitation to help other firms in their region comply with DPP regulations. Regulations emphatically transcend the different fields concerning DPPs. A strong regulatory framework should encompass regulations about product design, a facilitating set of rules for urban planners to advance and strengthen physical infrastructure, and regulations about governance issues inherent to industrial ecosystems that transcend institutional entities (e.g., municipality, province). This paper shows potential links between legal aspects and different research fields; however, this needs to be explored more in-depth by researchers in the legal field.

6.3 Improvement

Involve all relevant stakeholders and give them a shared mandate to improve the DPP.

Through the involvement of multiple stakeholders in discussing the findings of the holistic impact analysis, each iteration of the DPP design and implementation cycle can be improved upon. Relevant stakeholders include firms, industry associations, public bodies, local governments, knowledge institutions, consumer groups, non-governmental organizations, investment brokers, innovation intermediaries, and more. For example, digital platform cooperatives have emerged to govern and encourage data sharing as one step in achieving CE. This DPP improvement principle has a multi-stakeholder focus that will allow for a broad perspective on any negative social or environmental impacts, including potential geographical inequality, and stimulate agreement for continual support of and optimization of the DPP. Discussions on potential trade-offs need to be managed in an open process, with acknowledgement of differences of opinion about optimizing the overall value for all parties, a fair distribution among parties, or a pure focus on the ecological footprint.

7. Finance and Fundraising

The guiding principles, formulated through the integration of diverse discipline-specific expertise, serve as a strategic roadmap for financial stakeholders and fundraising efforts involved in the implementation of Digital Product Passports (DPPs). Tailored to industrial ecosystems (IEs) and public bodies, these principles prioritize system-level outcomes crucial for DPPs to effectively instigate the necessary changes to address environmental concerns. While my analysis considers various factors related to DPPs, ongoing research should explore whether the developed principles and orchestration framework are both mutually exclusive and collectively exhaustive.

The orchestration framework places a strong emphasis on the finance and fundraising aspects of DPP implementation, focusing on operational guidelines, adoption, and use across and within IEs. This approach aims to facilitate the transition to the Circular Economy (CE). While our study adopts a view that positions CE outcomes as the primary purpose of DPPs, it recognizes that DPPs entail broader implications, encompassing both intended and unintended consequences.

To enhance DPP implementation, insights from the successful adoption of global standards, technologies, and certifications, such as ISO or Extended Producer Responsibility (EPR) models, should be considered. Learnings from ISO certification highlight the importance of not solely focusing on auditing and certification processes but also on continuous improvement and internalization of learning. Similarly, EPR models showcase the need for harmonized legislation and a coordinating framework for effective implementation beyond individual firms. The proposed orchestration framework emphasizes engaging a multitude of relevant actors and addresses emerging governance, regulatory, and implementation challenges.

While the guiding principles offer valuable managerial and theoretical insights, certain financial and legal considerations must be acknowledged. The collaborative and incremental implementation approach recognizes DPPs as a normative instrument driven by the EU to facilitate circularity in the EU market. Future studies should explicitly examine the legal requirements and implications of implementing and using DPPs, considering evolving frameworks such as the General Data Protection Regulation (GDPR) and the Data Governance Act.

Despite increasing acceptance of circular business principles, Circular Economy (CE) systems are yet to be implemented at a meaningful scale. This study emphasizes the need for research from multiple scientific communities to assist individuals, business managers, investors, and policymakers in making informed financial decisions for successful CE transitions.

A critical challenge in informed decision-making for CE transitions is the access to comprehensive data, covering various stages of the product life cycle and multiple scales. Digital Product Passports (DPPs) bridge this gap, providing an infrastructure for managing and accessing structured data at both individual and scale levels. The proliferation of emerging ICT, particularly Artificial Intelligence and Machine Learning, can be facilitated by DPPs, enabling the adoption of innovative paradigms like Industry 4.0 and 5.0 in industrial ecosystems.

While the literature on DPPs is in its infancy, this paper contributes to understanding the nature,

functions, and technological underpinnings of DPPs, specifically focusing on their financial and fundraising implications. The transdisciplinary approach employed offers insights into how DPPs can contribute to the CE vision and guides financial stakeholders in making relevant choices for successful implementation. The proposed orchestration framework and guiding principles provide practical guidance for both industrial firms and orchestrators involved in inter-organizational DPP implementation.

8. Conclusion

Following the European Union's proposal for DPPs as the most promising approach to making production systems sustainable, the main message of this paper is that multiple perspectives must be considered when DPPs are designed and implemented to achieve the overarching goal of sustainable material flows, energy use, and reduced emissions.

The trans-disciplinary analysis described in this paper has highlighted key barriers and challenges relating to knowledge engineering at the micro-, meso-, and macro-economic levels, and this has led to the formulation of guiding principles for managers of firms involved in product production industrial ecosystems. There is a global imperative to transform our economies away from their damaging past and into a regenerative future, and DPPs are likely to form a cornerstone of this transformation; as such, they must be carefully designed and implemented.

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Strategic Framework for Agency in the Algorithmic Era: Unveiling the Mechanisms and Structures of Blockchain-Powered Organizational Strategies

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1. Abstract

Firms are increasingly adopting blockchains as a form of knowledge engineering to align their internal processes, share information, and improve oversight. We study intraorganizational blockchains from an agency perspective to understand how the distributed, sequenced, and consensus-based nature of blockchains mitigates information asymmetries and affects organizational structures. First, we explain how blockchains differ from conventional relational, contractual, and system-based mechanisms to address three pertinent information challenges—concentration, continuity, and conflict. Subsequently, we address the consequences of introducing such blockchains, arguing that they create both direct and sequenced information channels among principals and agents, which elicit an organizational reconfiguration via vertical disintermediation and lateral reintermediation. Finally, we theorize the implications of blockchain-based organizing for agency theory regarding the chain of command, the unity of direction, and the span of control. Overall, we show how blockchains for intraorganizational governance can mitigate principal-agent problems and impact organizational design in profound ways.

2. Introduction

Blockchains are being increasingly recognized as a governance mechanism in various contexts, encompassing both permissioned and permissionless networks (Beck et al., 2018, Cennamo et al., 2020). On the one hand, permissionless blockchains, including decentralized autonomous organizations (DAOs) and cryptocurrencies, rely on radical decentralization to establish systems without (or very limited) hierarchical structures, providing anonymity and unrestricted access to all transactions (Goldberg and Schär, 2023, Zhao et al., 2022). On the other hand, permissioned blockchains, such as IBM Food Trust and PharmaLedger, have garnered significant attention due to their efficacy in regulating interorganizational relationships and optimizing supply chain management through partial automation while preserving a level of security requisite for safeguarding the confidential and proprietary data of participating entities (Hanisch et al., 2023, Treiblmaier, 2018). As of late 2021, 81 of the 100 largest publicly traded companies have been using (mostly permissioned) blockchains (Blockdata, 2021). Both permissioned and permissionless blockchains have thus emerged as potential solutions to governance problems of accountability, transparency, and trust in different domains, offering the potential for novel forms of governance that can enhance existing structures or create entirely new systems of governance (Rossi et al., 2019). As such, the study of blockchain technology from a governance perspective represents a burgeoning field of research, with implications for a broad array of fields and industries (Lumineau et al., 2021, Tan and Saraniemi, 2022).

One area of blockchain governance that has received surprisingly little attention is its use within single organizations. Indeed, most of the literature on blockchain governance has focused on permissionless networks (e.g., Hsieh & Vergne, 2023) or permissioned interorganizational networks (e.g., Shew et al., 2022), but few studies have examined how blockchains can be deployed within organizations (e.g., Murray et al., 2021, Sharif and Ghodoosi, 2022, Yermack, 2017). However, as mentioned by the founder of Advatech Pacific, Deepanshu Khandelwal, "before thinking of achieving interorganizational efficiencies using blockchain, companies should look at leveraging

blockchain for intraorganizational efficiencies, which will be a tremendous use of this technology." Studying how blockchains integrate within hierarchical organizations is of considerable conceptual interest due to the clash between the decentralized nature of blockchains and the centralized structure of hierarchies. Additionally, hierarchical organizations scale vertically by adding more layers to the chain of command (Astley, 1985, March and Simon, 1958), while blockchains scale laterally by adding more blocks to a chain of data validated by network nodes, a fundamental difference in the scaling mechanisms of these two systems. In view of the technology's potential for intraorganizational governance and the inherent theoretical tension, there is a clear need for theoretical advancement that integrates blockchain into the debates on intraorganizational governance while studying the implications for organizational design.

Agency theory offers a suitable lens for examining blockchain technology in terms of intraorganizational governance by studying the potential conflicts and misalignments from information asymmetries between principals and agents. Through this theoretical lens, we provide a nuanced study of blockchain governance in intraorganizational settings, shedding light on its potential to reduce information asymmetries, complement and even substitute hierarchy-based process controls and fiat through its transparent and decentralized nature. We thus conceptualize blockchains as an algorithmic form of process control and argue that they can facilitate information distribution and sequencing, enabling organizational members to avoid information concentration while ensuring a continuous record of information. Additionally, we suggest that the blockchain consensus mechanism can alleviate the pressure on organizational supervisors to exercise hierarchical authority, that is, the formal authority that principals have over agents (Reitzig & Maciejovsky, 2015) to resolve conflicts via fiat, resulting in a potent form of internal digital governance (Hanisch et al., 2023). Our microlevel perspective of intraorganizational blockchain governance therefore suggests that blockchains can enable direct vertical information channels, flatten organizational hierarchy through vertical disintermediation, and create a process-oriented alignment based on a strict sequencing of agent tasks that can cause inefficient lateral reintermediation. Thus, blockchain technology can address crucial governance issues within organizations and facilitate new organizational structures, which come with potential downsides.

My paper makes three main contributions to the field of blockchain research in business and management (e.g., Hsieh and Vergne, 2023, Lumineau et al., 2021, Zhao et al., 2022). First, we provide a microlevel theory of how intraorganizational blockchains impact the principal-agent relationship, focusing on the unique governance mechanisms within organizations. We explore the implications of introducing a peer-to-peer system in hierarchical settings, examining the role redefinition of intermediaries such as middle managers in a digital governance context. Second, we advance discussions of blockchain governance by investigating how blockchains facilitate information channeling and rechanneling within organizations (Murray et al., 2021, Sharif and Ghodoosi, 2022, Yermack, 2017). Specifically, we address information distribution in hierarchical settings and highlight the benefits of reducing reliance on information aggregators through direct chains between principals and agents. Third, we contribute to the literature on organizational design (e.g., Huber, 1990, Puranam et al., 2014, Zammuto et al., 2007) by demonstrating how blockchains reshape organizational structures, connecting actors in direct ways that align with organizational processes and transcend traditional hierarchies. Overall, my paper deepens the understanding of how firms can leverage decentralized technologies such as blockchains to enhance accountability, transparency, and trust while retaining the benefits of hierarchical organizing.

3. Marketing Analysis

Governance in organizations refers to the rules, procedures, and processes that are used to control and coordinate the actions of its members—namely, principals and agents—to achieve their goals and objectives amid asymmetric information (Aguilera et al., 2015, Jensen and Meckling, 1976). Thus, the need for governance aimed at effective control and coordination stems from the prevalence of information asymmetries and agent opportunism

present in organizations (Gittell, 2000, Moon et al., 2004, Sharma, 1997, Sundaramurthy and Lewis, 2003). In organizational settings, information asymmetries result from the division of labor between task-giver (principal) and task-performer (agent), creating monitoring difficulties and potential incentive misalignments (Eisenhardt, 1989, Thiel et al., 2021). Information asymmetries can significantly harm organizations. For instance, information concentration, which can occur when "those who have valuable information are incentivized to invest in safeguards" to advance their self-interests (Bergh et al., 2019, p. p. 134), may lead to biased decision-making or suboptimal strategic decisions (Beck & Plowman, 2009). Similarly, the absence of information continuity across organizational silos and functions may result in organizational inefficiencies (Lessard & Zaheer, 1996), such as duplicate work and misunderstandings. Information conflict, whereby actors face contradicting information and disagreements on how to interpret it (Cronin & Weingart, 2007), can lead to erroneous communication or biases that influence the effectiveness of strategic decision-making (Nguyen, 2007, Papadakis et al., 1998).1 Amidst these information asymmetries within hierarchies, governance is a countervailing force that aligns interests, fosters cooperation, and enables coordination among organizational actors.

3.1. Blockchains as algorithmic process controls

In light of the governance challenges in organizations, blockchains offer an enticing opportunity to partially or fully automate governance and address the critical problems of information concentration, continuity, and conflict via algorithmic process controls (Hanisch et al., 2023). Blockchains are characterized by peer-to-peer validation and the immutable storage of transactions in a shared, distributed ledger (Schmeiss et al., 2019, Yuan and Wang, 2016). The distributed nature of blockchains reduces the likelihood of information concentration and tampering by storing information in a network-managed database accessible on every node in an organization's network (Chod et al., 2020, Vergne, 2020). Additionally, blockchains sequence information and thus track missing data, ensuring an immutable and append-only database that facilitates sequenced workflows (Clohessy et al., 2020). Finally, the consensus-based approach of blockchains enhances process monitoring via agreement across the nodes in a system, verifying information and executing smart contracts programmatically (Murray et al., 2021). Notably, to achieve such automated governance, blockchains require explicit information, such as financial data, contracts, and formal workflows, but have lesser utility for tacit information that involves context-specific knowledge or interpretation (Lumineau et al., 2021).

BMW's collaboration with DHL on an internal blockchain project provides a practical example of how blockchains can automate internal governance through process controls (BMW, 2020). Specifically, BMW sought to address the concentration of information on parts supply in certain departments and the lack of communication regarding supply disruptions across all its production units. By using blockchain technology to track such internal processes, BMW enhanced the visibility of its Asia Pacific supply chain operations, reducing the need for manual reporting, especially concerning delayed part shipments. This meant that stakeholders could access the data they needed, resulting in improved process transparency and faster problem resolution. This successful implementation highlights the potential of blockchains to improve information sharing and organizational efficiency (Ledger Insights, 2019).

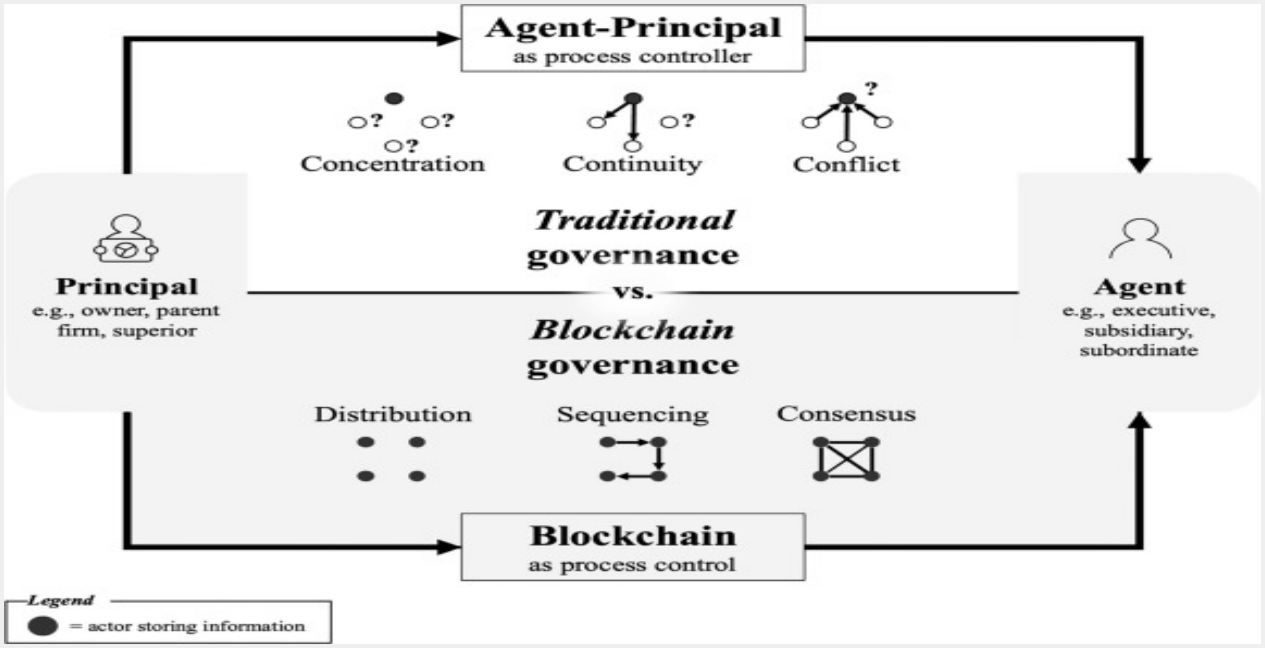

Fig. 1. Blockchain vs. Traditional Governance.

Fig. 1 illustrates the contrast between traditional governance at the top and blockchain governance at the bottom conceptually. Specifically, it presents the theoretical logic of how blockchains can help address the information challenges encountered by organizations, such as concentration, continuity, and conflict, stemming from their distinctive characteristics of distribution, sequencing, and consensus. The shift towards blockchain governance chiefly affects those who act as "agent-principals" (e.g., middle managers) who report up and delegate work down the hierarchy (Dutton and Ashford, 1993, Van Doorn et al., 2022). These roles serve as human process controls that aggregate, filter, and transmit information between the principal and the agent; all of these functions are increasingly transferred to blockchain technology. Although blockchains can enhance accountability and transparency within organizations, it cannot alter the intrinsic motivations of principals and agents, such as self-interest and opportunism. Nonetheless, it can introduce an algorithmic process control that reduces the wiggle room for action on tangential motives. By offering an immutable record of transactions and interactions, blockchains can expose and thereby prevent fraudulent or unethical conduct. As a result, agents may be encouraged to share even more information to demonstrate compliance and diligence in their duties. Furthermore, the blockchain's smart contract capabilities can provide a level of automation and transparency that can reduce the potential for errors or intentional misrepresentations. Thus, while blockchain technology cannot alter individual motives, it provides a digital governance layer that can help curb the consequences of self-interested and opportunistic behavior.

The case of Ericsson—a communications company based in Stockholm—is especially apt to explain how blockchains can be used to solve efficiency issues internally (Day, 2023). Ericsson deployed an internal blockchain to facilitate the invoice process across the company's units. Specifically, the company encountered inconsistencies in the flow of purchase orders against the flow of invoices, which had been cumbersome given the many legal entities under the same corporate umbrella: "Basically, there are two flows of information that at the end have to reconcile somehow," in the words of the head of blockchain at Ericsson, Giovanni Franzese. An internal blockchain allowed various entities within Ericsson to increase trust among each other and improve the traceability and visibility of the intercompany invoice process. "For the first application we developed, it was 95 % of savings by lead time," explained Giovanni Franzese. What stands out in the Ericsson case is their decision to use blockchain internally: "There is a level of centralization. But this is perfectly right because otherwise you could not prevent a loss of control if you had full decentralization within companies where you're using a blockchain solution." Similar to the Advatech Pacific case above, Ericsson is

currently leveraging blockchain governance internally with plans to expand the technology to an interorganizational network in the future: “You need to start humble; you need to start with some control and then as long as you take heart, then you release control in a more decentralized way.”.

3.2 How blockchains rechannel information

The blockchain’s unique characteristics offer new ways of addressing the information challenges that arise between principals and agents that are not possible when employing traditional approaches to governance based on relational mechanisms, contracts, or enterprise resource planning (ERP) systems. In this section, we emphasize the ways in which the distributed, sequenced, and consensus-based nature of blockchains differs substantially from the diffused, disconnected, and fiat-based mechanisms of relational and contractual governance in the context of principal-agent exchanges. Similarly, we contrast the features of blockchains to those of ERP systems and demonstrate how the former’s consolidated, interfaced, and synchronization-based nature nonetheless allows for information asymmetries in organizations. For instance, my discussions with managers indicated that blockchains can “make the exchange of information between participants more efficient,” (manager of a blockchain in an electrical company), which sparked my interest in how blockchains differ from other forms of governance. In the following section, we incorporate relevant quotations from my interviews with managers of internal enterprise blockchain networks to illustrate the mechanisms underlying the use of blockchains in organizations and support my theorizing, highlighting the key differences between blockchains and traditional governance approaches.2

In practice, managers often struggle with the problem that information is scattered throughout the organization and is thus difficult to access reliably; it is also challenging to determine whether the stored information is accurate and up to date. This problem can be solved through the blockchain’s distribution of information (Akoramurthy & Kumar, 2020). For example, one manager of a blockchain in the oil and gas industry mentioned how “the idea was a reduction in the existing processes and hydrocarbon reconciliation time and then, more importantly, to secure an immutable ledger of all quantities that are recorded in the distributed ledger.” Another manager of a blockchain for military purposes explained how “[the blockchain] was tracking aircraft parts across internal organizations and systems as they moved throughout their lifecycle to provide a single source of truth regarding the status and life span of an aircraft part at any given time to relevant parties and to secure the audit trail for an aircraft part.”.

From a conceptual perspective, when organizations rely primarily on relational (e.g., Claggett and Karahanna, 2018, Fahn and Zanarone, 2021) and contractual governance mechanisms (e.g., Jensen and Meckling, 1976, Magelssen et al., 2022), information is diffused in the form of organizational routines and experiences and stored in procedural memory (Cohen and Bacdayan, 1994, Howard-Grenville, 2005, Omidvar et al., 2022), which can be supplemented by consolidated and centralized records in ERP systems that store, integrate, and control certain kinds of information (Berente et al., 2016, Morton and Hu, 2008). A negative consequence of these two mechanisms is that information can be transmitted inaccurately (e.g., parties can have their own interpretation of information), or it can be manipulated in centralized systems by authorized actors (e.g., data can be overwritten). In contrast, blockchains offer a solution to concerns regarding such information concentration because the information is distributed across multiple nodes in the system, thus eliminating the need to rely on widely diffused and inaccurate experiences or information contained in centralized systems that are prone to tampering.

Such a blockchain has been deployed by Coca-Cola, which depends on the reliable exchange of information among bottling companies to fulfill orders (Business Insider, 2021). Together with the technology provider SAP, Coca-Cola has created a platform that enables the sharing of stock supply, order information, and delivery times in a transparent and immutable manner. By testing this platform with Coke One North America (CONA), Coca-Cola aimed to reduce its reconciliation times from an average of 50 days to less than a week (Bitvalex, 2019). The success of this implementation has led CONA to extend its use of blockchain technology to a larger audience. The

company now utilizes the Baseline Protocol to establish a frictionless network joining process among Coca-Cola Bottling's suppliers, providing benefits not only to internal bottlers-suppliers but also to external suppliers of raw material. The Baseline Protocol heavily relies on Zero-Knowledge Proofs (ZKP), a type of encryption that verifies information without exposing it, ensuring that competitors cannot access smart contract contents or volume discount details (Cacioli, 2020). Hence, by using blockchain technology, Coca-Cola has created tamper-evident records of all transactions, providing efficient and cost-effective algorithmic process controls.

In addition to addressing the challenge of information concentration, blockchain technology can facilitate coordination within organizations that have internal boundaries separating different departments and functions (Wang et al., 2022). By using blockchain technology, organizations can create a shared, tamper-proof ledger that all parties can trust and use to track their interactions. This can help to break down organizational silos and promote transparency, accountability, and collaboration across different units. With the use of blockchain technology, managers can ensure that information flows accurately from one unit to another and leaves a comprehensive audit trail that is accessible by all parties involved. Accordingly, this can help prevent information leakage or quality deficiency and provide a secure channel for organizations to collaborate and improve their processes.

From a theoretical perspective, information continuity in analog organizations is complicated by the facts that information is often fragmented across compartmentalized organizational units and that such organizations require dedicated interfaces in the case of ERP-based information sharing (Barki and Pinsonneault, 2005, Garvin, 1998, Morton and Hu, 2008). Blockchains solve the problem of information gaps because different pieces of information build sequentially on top of each other (i.e., the input order is controlled). Thus, the order, adherence, and interdependence of processes can more easily be controlled. For example, Chem-Corp (a pseudonym), a medium-sized chemical company in the northern Netherlands, implemented a blockchain solution to organize its internal processes based on the internal blockchain technology developed by NorthChain (2021).3 Part of this solution involved modeling Chem-Corp's internal processes through a flowchart and using a proprietary blockchain code compiler to translate this process diagram automatically into blockchain code. An immediate consequence of using a blockchain and the strict control, transparency, and immutability that this approach facilitates was the realization that production frequently deviated from the laboratory's chemical formulations, resulting in more than ten percent of production going to waste. With the introduction of the immutable logs recorded by the blockchain, these issues were quickly detected and traced to their origin, and production waste was reduced to zero after production fully adhered to the laboratory's prescriptions.

Third, managers tend to face conflicts when multiple records of information exist and they are unsure which information to believe in. Blockchains can create machine-based consensus (Lumineau et al., 2021), which helps resolve conflicts and misalignments. In one interview, it became apparent that NorthChain had improved the way one of its construction clients addresses information conflicts. Previously, the client had relied on inefficient weekly management meetings to review project status, during which "the CEO would ask middle managers questions like 'are there any problems?', and these middle managers would go to their project managers and ask [the same question]." This led to delayed, conflicting, and vague information sharing regarding all the client's projects. Instead, the construction client "wanted to have real-time information on the status of each project at all times, and [it] wanted to prevent issues exceeding time and budget," according to Herman Balsters from NorthChain. Thus, by using blockchain-based smart contracts that automatically execute payment transfers once specific milestones in the construction process are reached, the construction firm could rely less on conflicting information from middle managers and, rather, ensure that payments were made directly, promptly, and accurately, reducing the risk of payment dispute and promoting timely project completion.

In conceptual terms, information conflicts in the organizational hierarchy are resolved through fiat (Williamson, 1991), such that the principal enforces

Table 1. How Blockchains Address Three Central Information Challenges.

		Relational / Contractual	Traditional ERP *	Blockchain
Information challenges	**(1) Concentration**	**Diffused** information stored in memory and documents	**Consolidated** information stored in central systems	**Distributed** information dispersed across nodes
	(2) Continuity	**Disconnected** information dispersed across units	**Interfaced** information shared through dedicated interfaces	**Sequenced** information ordered across units on a state-by-state basis
	(3) Conflict	**Fiat-based** resolutions enforced via principals by matching information	**Synchronization-based** resolutions enforced via centralized updates after entering information	**Consensus-based** resolutions enforced automatically before entering information

Notes: * Enterprise Resource Planning.

Table 1. How Blockchains Address Three Central Information Challenges

the information record based on authority or via centralized ERP systems that synchronize information, which can reveal conflicts but nevertheless require decisions concerning how to resolve those conflicts. Blockchains resolve information conflicts such as double-spending problems (e.g., a budget is inadvertently expended twice by different individuals) because each transaction on the blockchain is validated by a peer-to-peer network that by design prevents a transaction from being executed twice. This blockchain-native feature is already being used in many interorganizational contexts. For example, the blockchain-based solution for automotive supply parts, Vinturas, solves the problem of information conflicts between automotive suppliers and original equipment manufacturers (OEMs) by producing an immutable log of parts logistics, which is updated in real-time and communicated between logistic service providers and OEMs (Vels, 2021). The fact that all information is recorded in the Vinturas blockchain improves the reliability of the data as well as the transparency of the business process for all involved parties. In Table 1, we offer a comprehensive overview of this situation, illustrating the fundamental differences of blockchains from relational, contractual, and ERP-based governance mechanisms.

As an additional, practical example, HerenBouw, an Amsterdam-based building company, has leveraged blockchain-based project management to improve its building development efficiency in commercial real estate (Magazine, 2022, Tapscott and Vargas, 2019). Particularly, blockchain was used in a large harbor development project to register transactions and ensure accuracy and auditability. One of the challenges in the sector is the management of large teams of contractors and subcontractors, building codes, safety regulations, and standards. To address this, HerenBouw used a blockchain to track subcontractors and their tasks through a “reputation ledger,” which served as a benchmark for the recruitment process. Moreover, a lifecycle ledger was used to store warranties and certifications, protect the construction process from tampering and fraud, and maintain a record of events in the lifecycle of the building. As Bassem Hamdy, CEO of Brickschain Construction Blockchain Inc., noted, “the power of [the] blockchain is that it creates very powerful standards, in a simple-to-adopt way that

doesn't interfere with current processes" (Lopes, 2019).

4. Competitive Analysis

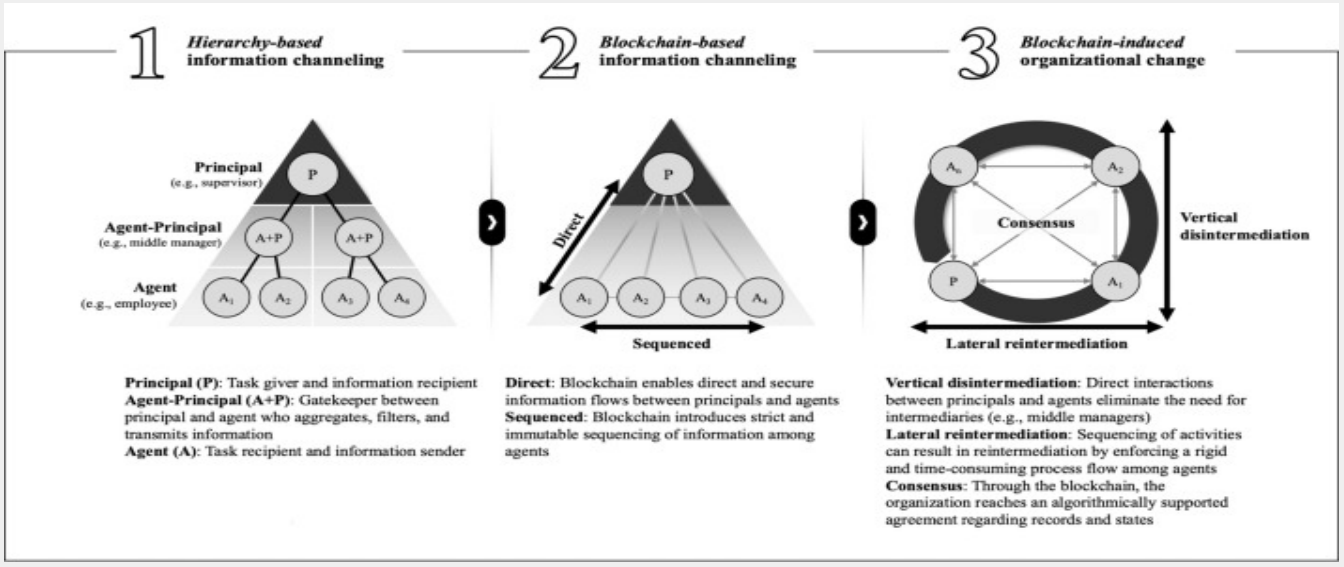

Fig. 2 Information Channeling and the Resultant Organizational Reconfiguration.

We continue our theorizing by examining the ways in which the implementation of intraorganizational blockchains affects the information channels between principal and agents and, consequently, the organizational configuration in which these actors operate. Specifically, internal blockchains introduce vertical information channels that link principals and agents directly, as well as sequenced horizontal information channels that arrange agent tasks in a chained lateral process. These omnidirectional information channels (Romme, 1999, Romme, 2004) are expected to reconfigure the focal organization in terms of vertical disintermediation and lateral reintermediation, respectively. We demonstrate how, taken together, these two reconfigurations create a structure that facilitates organization-wide consensus. By connecting the organizational information channels enabled by blockchains with organizational structure, we lay the foundation for a more profound understanding of the implications of blockchains for organizations. In the following, we describe the reasoning underlying my claims and display the identified mechanisms visually in Fig. 2.

To study the implications of blockchains for organizations, we must first understand the prevalent information channels in archetypical hierarchical organizations. Conventionally speaking, a hierarchy is constructed in a way that enables "top down" information channeling across multiple actors. Information channeling refers to the active, bidirectional provision of information and its subsequent receipt, processing, and storing in the relationship between principal and agent. For instance, a typical hierarchy includes a principal, such as a superior, who transmits information (e.g., work, tasks, states) to an agent. As the amount and scope of such information grows, a typical organizational response is to institute additional levels of the hierarchy, thereby simultaneously introducing more intermediary principals and agents to manage the newly emerging complexity (Astley, 1985, Lawrence and Poliquin, 2023). As a result, hierarchical growth inevitably leads to an "agent-principal duality" among some roles, e.g., for middle managers (Dutton and Ashford, 1993, Van Doorn et al., 2022), who report to their superior (the principal) and simultaneously delegate work to subordinate agents, e.g., regional sales managers or plant managers. The hierarchical organization embeds such dual roles as critical nodes to process information provided by principals and to translate it into coordinated work for agents as well as to communicate aggregate status and process information from the agent back to the principal to facilitate further review and decision-making (Rouleau, 2005). Hence, hierarchies tend to create

top-down information channels flowing from principals who assign the task to agent-principals who assume responsibility for bidirectional information processing and then to the agents who ultimately carry out the work.

Blockchain enables principals and agents to exchange information directly, reducing the need for human-mediated information processing and providing the capacity to eliminate information asymmetries. Typically, "agent–principal" roles are responsible for information processing as well as gathering and interpreting agent information, in addition to translating principal information into manageable tasks for agents to accomplish. These roles thus become increasingly obsolete when the blockchain stores all relevant information in a tamper-evident, distributed ledger, which entails that principals can retrieve status-related information and validate it directly in the blockchain (e.g., quality gate approvals, legal signatures), while the agents input information directly to the blockchain as their work progresses. In doing so, the blockchain guarantees that information is channeled directly between principals and agents, even in large organizations (Tourish, 2005, Tourish and Robson, 2006). The use of an internal blockchain without intermediaries grants the principal access to an unbiased and undistorted view of the organization's state, facilitating processes or the reconstruction of events during crises (e.g., product recalls, customer complaints). One partner at NorthChain, Herman Balsters, expressed this situation as follows:
In a certain way, the blockchain is the middle manager. Because the blockchain is consistently controlling and steering what happened and will happen. […] Middle managers tasked with coordination and control responsibilities for these types of activities and processes can be replaced to a certain extent.

Blockchains therefore enable improved vertical information channels, which in turn leads to a reconfiguration process of vertical disintermediation (Chircu and Kauffman, 1999, Clohessy et al., 2020). Two areas of such disintermediation can be expected. First, blockchains render dual agent-principal roles, such as middle managers as information processors, obsolete, leading to the downsizing of organizational hierarchy (Balogun and Johnson, 2004, Kohli and Liang, 2021). Second, by translating all information for storage into blockchain records, organizations can identify and address structural gaps that produce redundancies, leading to the elimination of inefficient or useless roles or groups of roles (Pinsonneault & Kraemer, 1997). This transparency achieved through direct information channels allows organizations to uncover redundant roles and departments, such as those that exist solely for the purpose of auditing the practices of other departments. As Stefan de Ruiter, partner at NorthChain, explained, these direct, peer-to-peer connections among agents could eliminate certain business functions:
[Using the blockchain], it is easier for higher managers (e.g., the CEO or line managers) to get their KPIs and other management information directly. It is easier for them to acquire that information. And, depending on the firm's needs and wants, it is no longer required for subordinates to report to managers, as managers automatically have access to this information. […] We did see the elimination of almost an entire department.

However, while blockchain-induced vertical disintermediation provides transparency and efficiency benefits, its append-only and immutable nature may cause information overload, leading to decision paralysis and negatively affecting decision-making processes (Junge et al., 2023, Reutskaja et al., 2020). That is, as Simon (1971, pp. pp. 40-41) famously indicated, "what information consumes is […] the attention of its recipients." By eliminating the role of information processors, who filter and transmit relevant information (Beck and Plowman, 2009, Guth and Macmillan, 1986, Schilt, 1987), a blockchain thus transmits all information in an unfiltered fashion. According to NorthChain, this impairment can only be resolved at the application level: "managers only see the actual workflow being done; not the technical details of the underlying blockchain implementation." Failure to address this issue could obstruct decision-making by increasing the difficulty for managers to acquire and process the most relevant information, which could impact strategic, private, or political decision-making (Aldrich and Herker, 1977, Stevenson and Gilly, 1991). Additionally, the lack of middle management for information filtering and transmission may impede agent execution at the operational levels of the focal organization because agents often rely on intermediary roles for clear and prioritized

instruction to achieve strategic goals (Shi et al., 2009). Finally, downsizing the organization can result in less "issue selling" from middle management toward top management (Dutton & Ashford, 1993, p. 407), which, in a blockchain scenario, rests solely on agents or principals that might lack the time, resources, knowledge, skill, or motivation to drive strategic initiatives themselves. Ultimately, while blockchain-induced vertical disintermediation holds promise for a flatter and more efficient organizational structure, it may come at the cost of increased cognitive load for organizational actors due to its higher information volume.

4.1 Sequenced information and lateral reintermediation

The top-down, vertical information channeling that occurs in the hierarchy discussed previously demonstrates a second important characteristic of hierarchies, namely, the fact that the hierarchy is structured in a way that constrains horizontal information channeling (Knight, 1976, Lu and Wedig, 2013). Because the hierarchy relies on information channels between principals and agents and because agent information needs to be reported back to principals, the archetypical hierarchy does not facilitate or reward sideways information channeling among agents. This lack of communication can result in missed opportunities for synergistic agent-to-agent exchange, which could improve the overall process. Even though the principal may assume that they know all the information that is required to make the best decision for both agents, the principal cannot know what is not shared or what is withheld by non collaborating agents or what those agents may have gained by working with each other. Since they tend to facilitate top-down and bottom-up information channels, hierarchies tend to understimulate the diversified information sharing among agents that is necessary for cross-functional alignment (Aalbers et al., 2016).

A blockchain has the potential to connect agents directly via a peer-to-peer network, which can promote horizontal information channeling across functional silos (Akoramurthy & Kumar, 2020). Specifically, blockchains connect each actor involved in a given process using "permissions," which are programmatic ways of assigning roles, responsibilities, procedures, and objectives to physical human agents via the blockchain. In our interviews with NorthChain, such permissions in the internal blockchain context were viewed as "a certain authorization to perform some step in the process." By connecting agents directly and enabling the required level of agent authority, the blockchain improves the channeling of horizontal information, as agents are not disconnected via the mediation of a principal but are rather tied together systemically for equivalent or related business processes. Herman Balsters further explained that "the process model will be the organizational blueprint of how you are going to work […]. So, the process model is going to be all-important if you are going to do this horizontal integration." This horizontal agent tie in the context of common business processes is particularly valuable when the agents could benefit from project-specific but relevant knowledge (Hansen, 2002), when agents are associated with competing units (Tsai, 2002), to reduce the distortions in communication between various units (Albaum, 1964), or simply when increased information diversity is a relevant aim (Aalbers et al., 2016). A blockchain can even automate step-by-step progression from agent to agent, e.g., when a task is verified as complete and not missing additional input, which renders agent communication near-autonomous (e.g., via smart contracts that are automatically executed given predefined conditions). Thereby, the blockchain improves agent information channeling and interdependence in a horizontal fashion and reduces the need to assign this capability of facilitating information flows among agents to a middleman.

Paradoxically, while vertical disintermediation results from direct information channels, a blockchain can introduce a novel form of lateral reintermediation among agents who are separated by mediating agents in the context of a formalized workflow. Lateral reintermediation occurs when agents in the blockchain are obligated to collaborate due to the rigid programming of the blockchain, even if the agents in question are organizationally separated by their inclusion in different segments of the hierarchical strata (Dahlander and O'Mahony, 2011, Galbraith, 1994, Hinds and Kiesler, 1995). This situation occurs because a blockchain operates in sequential phases, such that each task performed and recorded by one agent is reviewed and

continued by other agents. Herman Balsters from NorthChain explained this rigidity as follows: "everybody involved agrees on how the process is to be executed […] and no deviation from the agreed upon process is possible." In some instances, such horizontal ties may facilitate peer-to-peer interactions that would not have occurred naturally, which may prove to be useful. For example, if agents work in different geographical locations and if the output of one production plant serves as input for another, a blockchain could provide a reliable line of rich information exchange among agents, whereby prior to the implementation of the blockchain, direct interactions would have been rare. Although a blockchain can be used to transmit richer information from agent to agent, which offers clear benefits, an inflexible development process may emerge, such that it is difficult for agents to skip steps in the process and thereby bypass predesignated agents (Downs, 1967, MacCormack et al., 2001). In neglecting these often invisible and informal "behind the scenes" processes, blockchains fail to account for informal organizational structures (Soda & Zaheer, 2012). Consequently, blockchain-induced lateral reintermediation can ultimately prolong organizational processes and increase inefficiencies.

While lateral reintermediation has certain downsides in terms of the rigidity and strict lateral channeling of information, the blockchain that enables it provides new ways of monitoring and enables novel incentives for information sharing among agents. On the one hand, blockchain-induced lateral reintermediation facilitates a form of "agent-to-agent" monitoring (Homburg et al., 2020, Varian, 1990) that shifts monitoring activities away from principals and toward agents who have a clear stake in the information chain. This can lead to an increase in agent accountability and reduce monitoring costs for principals. On the other hand, blockchain technology allows for clear identification of which agent contributed what information, promoting transparency, reducing subjective performance measures on which agent incentives are based (e.g., Baker et al., 1994), and reducing wiggle room for free riding (e.g., Jones, 1984). For example, the use of smart contracts in a blockchain can incentivize agents to share information by automatically rewarding them for their contributions to the collective effort (i.e., "who did what and at which time," in the words of Herman Balsters). Hence, by facilitating diversified information sharing among agents, the lateral reintermediation of blockchains can help achieve cross-functional alignment, which is essential for the efficient and effective functioning of an organization (Aalbers et al., 2016).

As a result of vertical disintermediation and lateral reintermediation, the blockchain's algorithmic transaction protocol increases organization-wide consensus (i.e., an algorithmically supported agreement regarding records and states), ultimately contributing to the alignment of organizational processes and facilitating goal pursuit. On the one hand, vertical disintermediation produces a bidirectional line of reporting that principals can use to align and update information. Vertical disintermediation creates consensus because the relevant information becomes more transparent, reliable, and constantly monitorable by all parties (we illustrate this point in the networked structure displayed on the right side of Fig. 2). On the other hand, lateral reintermediation establishes a sequenced flow of information among agents, which the principal can use to initiate a workflow and agents can use to advance the workflow in a sustained matter without having to rely on further guidance or approval from principals. Similarly, lateral reintermediation contributes to the organization's level of consensus because the desired workflow is programmed into the blockchain, which limits deviations from the intended processes. In simple terms, a blockchain increases organization-wide consensus because it distributes information and reorders the ways in which organizational actors work to achieve a common outcome. In the words of Herman Balsters from NorthChain, "[the blockchain] amounts to a transparent, traceable, safe, and logged process. The involved parties work in networked setting, with no need for hierarchy.".

I conclude my argument with the example of Allianz, a global insurance company that has successfully implemented enterprise blockchain technology to improve its claims management processes (Ledger Insights, 2021). This insurer chose blockchain technology because it provides controls that naturally align with its needs in internal claims processes, e.g., to codify, audit, and

mandate the reconciliation of claims. For example, without the blockchain, a customer insured by Allianz Hungary involved in a car accident in France would trigger a cumbersome back-and-forth email process among Allianz' legal entities taking weeks to resolve. With its blockchain technology, when a customer submits an automobile accident insurance claim, Allianz can log data such as policy number, claim number, countries involved, and other details on the international claims portal connected to the country's node on the blockchain network, spurring cross-border collaboration and breaking down otherwise siloed entities. The blockchain also streamlines governance among legal entities through smart contracts, which automatically determine how claim costs are to be shared across organizations (i.e., "burden-sharing") in accordance with local tax law. By deploying Hyperledger Fabric across 23 internal companies, Allianz has thus ensured a single source record of any decision on each claim, significantly reducing administration times from weeks to minutes and providing faster claim settlement for customers. While introducing this technology has presented several challenges to Allianz, such as ensuring internal stakeholder alignment and raising awareness for the technology, the company intends to open its blockchain network to external organizations in the future.

5. Product Design

In the previous section, we explored the ways in which blockchains facilitate unobstructed channels of information within the organization, thereby enabling an organizational reconfiguration that features elements of vertical disintermediation and lateral reintermediation. We now examine how blockchain-based organizing may advance, challenge, or extend agency theory, which has focused on the hierarchical and bureaucratic organization as the predominant organizational form (Monteiro & Adler, 2022). Because organizations are essentially multiagent systems that have system-level goals, it is important to understand the context in which principals and agents work together to achieve their systemic goals (Puranam et al., 2014). Extending my prior arguments, we explore three possible changes with respect to the organization's (1) chain of command, (2) unity of direction, and (3) span of control. Fig. 3 presents these implications visually.

First, a blockchain-based perspective on organizing deviates from the traditional view of organizing proposed by agency theory in that the chain of command becomes significantly flatter in the former case, thus reducing the number of contracts that govern the individuals within the organization (Dutton and Ashford, 1993, Jensen and Meckling, 1976). By definition, the chain of command in an organization ensures that principals can divide and assign tasks to agents and provide the information necessary to complete these tasks. In conventional hierarchies, the chain of command is constructed to contain intermediary roles, such as those of middle managers, who are responsible for aggregating and disseminating information (in both top-down and bottom-up ways), which is an important aspect of such hierarchies that allows them to manage complexity. In contrast, the blockchain's chain of command contains the principal and agent roles only due to vertical disintermediation. Accordingly, principals and agents can interact directly without any intermediaries. The upside of this difference is that information can be transmitted in an unfiltered way to allow the principal to select the information on which they should act. The downside is that the principal's cognitive load increases with each additional agent reporting to them via the blockchain, hence slowing both strategic and tactical decision making. Overall, the chain of command becomes flatter following the implementation of a blockchain since fewer intermediary roles are required to reach the same organizational outcome.

Second, a blockchain-based perspective on organizing presents a challenge to agency theory because the unity of direction in blockchain-based organizations is far more autonomous and less dependent on principal intervention. The unity of direction ensures that agents work together cross-functionally to reach a desired organizational outcome. In a prototypical hierarchy, the unity of direction is established by the principal, who institutes process controls that are continuously monitored (Wiseman & Gomez-Mejia, 1998). Ultimately, it is the principal who monitors the progression and alignment of agents within the hierarchy and who shares with agents a variety of information that is necessary for cross-functional alignment (Aalbers et al., 2016). By introducing a

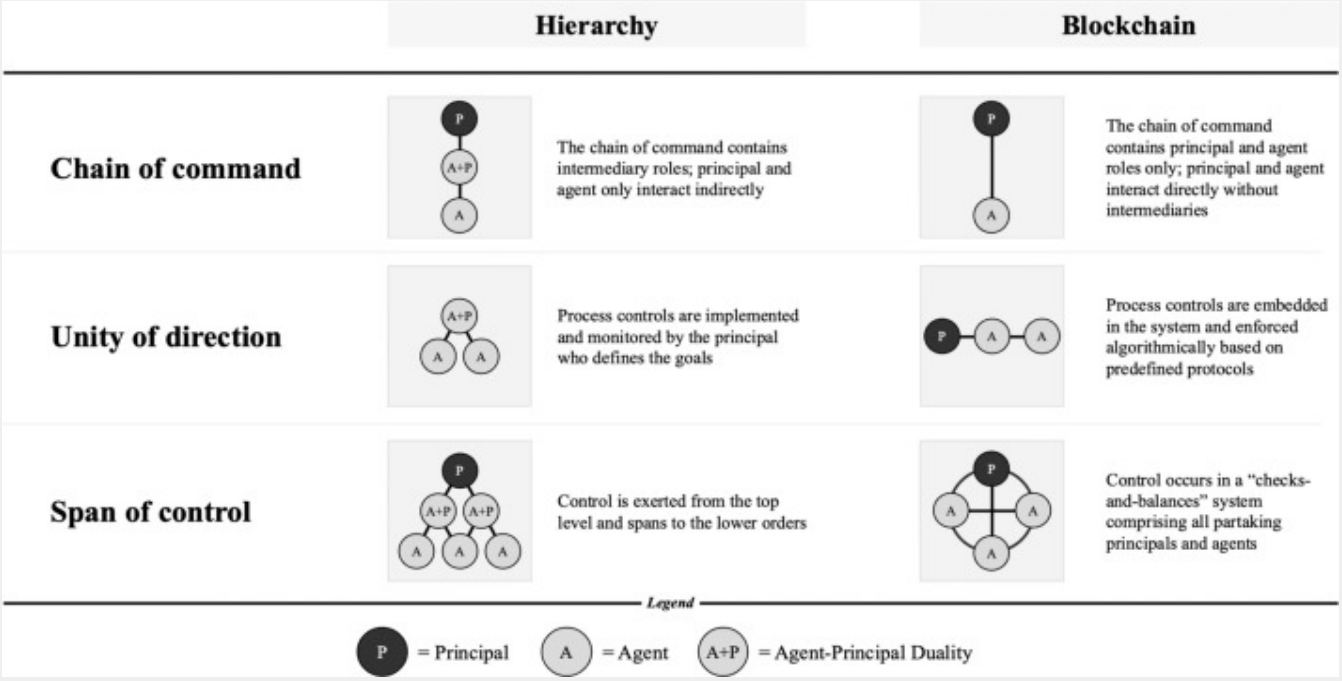

Fig. 3. Implications of Blockchain-based Organizing for Agency Theory.

blockchain-enabled process, the unity of direction is embedded in the system directly and enforced algorithmically based on predefined protocols. Accordingly, agents are incentivized by blockchain-based controls to act responsibly, as the embedded contract becomes more process-oriented. The upside of the blockchain in this context is that agents are connected to one another directly (i.e., due to lateral reintermediation) and hence do not require constant input from the principal to complete tasks and pass on state-based information. A critical downside is that agents rely less on human interaction and thus may become repetitive with regard to their routines, leading to a more monotonous, less creative organizational environment. In summary, the unity of direction becomes more self-sustaining due to the implementation of a blockchain because less direction from principal roles is required for agents to sustain their workflow and reach outcomes in a self-sufficient manner.

Finally, a blockchain-based perspective on organizing extends agency theory by demonstrating how the span of control in organizations governed by blockchains can reduce principals' control and increase agents' control in the form of a peer-to-peer network. The span of control refers to the way in which control is exerted to ensure that principal and agent outcomes and behaviors are consistently optimal. Hierarchies typically allow principals to exert control from the top, which extends to the lower orders of the hierarchy and ensures that agents comply with the principals' expectations. Blockchain-based organizing enables both principals and agents to exert control in the form of a "checks-and-balances" system in which all relevant actors participate, demonstrating the fact that this logic does not apply exclusively to principals. A checks-and-balances system emerges because the blockchain includes embedded consensus mechanisms that must operate over multiple nodes, and principal nodes alone would likely not suffice to meet the verification needs of an entire organization. The upside of such blockchain-based organizing is that the organization, as the sum of its actors (principal and agent nodes), is constantly monitored by all participants regardless of their rank in the organization, which can reveal suboptimal behaviors at all levels. The downside is that accountability in a blockchain-based organization can continue to be unequally distributed (e.g., via a proof-of-authority consensus mechanism), which gives higher weight to principals' votes and lower weight to agents' votes and effectively preserves an

unbalanced hierarchy in the design of the organization's consensus mechanism. In fact, a senior manager implementing an internal blockchain for an automotive client highlighted the "challenges of identifying neutral nodes required for consensus mechanisms within the hierarchy" due to status and role identities and questioned whether "[…] neutrality is even wanted by managers." Overall, however, the span of control becomes more multilateral following the implementation of a blockchain, giving less voice to principals alone and offering more room for agents to hold principals and peers accountable.

6. Marketing Plan

My heorizing has highlighted the implications of using blockchain in organizations for their governance and design. Broadly speaking, we build on the notion that the distributed, sequenced, and consensus-based nature of blockchains has the potential to reduce information asymmetries within the organization, which in turn mitigates principal-agent problems and enables new organizational structures. Building upon agency theory (Eisenhardt, 1989, Jensen and Meckling, 1976, Mitnick, 2021), we propose a fresh interpretation of blockchains that shifts the focus from the conventional interorganizational perspective to a microlevel, intraorganizational outlook, which distinguishes my work from previous blockchain-related research. We demonstrate how blockchains can resolve specific challenges related to information concentration, continuity, and conflict and explain the ways in which these challenges are provoked through principal-agent information asymmetries (Fig. 1). We also elaborate on how blockchains can address governance-related information challenges differently compared to relational/contractual and ERP-based governance mechanisms (Table 1). On this basis, we show how principal-agent information channels change due to the blockchain's distributed and sequenced nature and demonstrate how these changes ultimately lead to organization-wide information consensus among principals and agents and impact organizational design (Fig. 2). As my final contribution, I will highlight the key implications of blockchain-based organizing for agency theory (Fig. 3).

5.1. Theoretical implications

Most importantly, my study extends the conceptual foundation for enterprise blockchains, an emerging and impactful technology (Lacity, 2018, Lumineau et al., 2021), by examining the mechanisms underlying the use of blockchains for organizational governance. We justify this extension on the grounds that most blockchain research has thus far focused on cryptocurrencies and interorganizational applications (Cheng et al., 2019, Chod et al., 2020); insufficient consideration has been given to understanding the governance mechanisms involved in the use of blockchains for intraorganizational purposes (Goldsby and Hanisch, 2022, Murray et al., 2021). We wish to draw attention to the theoretical mechanisms associated with internal blockchains as a specific and less understood application of that technology by focusing on internal processes and governance of the hierarchical firm. As blockchain technology matures, we also expect to see an increasing number of applications of internal blockchains in the business world with potentially significant implications for organizational structures. By linking blockchains to firm-internal governance problems, we also transform our understanding of governance as a "nexus of contracts" (Jensen & Meckling, 1976, p. p. 311) by developing the conceptual basis for an interpretation according to which blockchains can form the basis for a "nexus of smart contracts" that mitigates alignment and contract enforceability problems (Magelssen et al., 2022).

On a broader note, blockchains are part of a larger trend of digital transformation driven by a variety of different and complementary technologies (Hanelt et al., 2020, p. 13). Next to blockchain, AI is another example of how digital transformation is shaping organizations. For example, Dixon et al. (2021) have studied how adoption of automated processes inside organizations can lead to a decrease in the total number of managers, and that those managers who are retained in the organization increase their span of control, which speaks to my propositions of vertical disintermediation, and opposes my propositions with regard to the span of control, which shifts toward agents and does not solely rest on managers. Moreover, new forms of opportunism are set to emerge in the AI context as well. For example, Kellogg et al. (2020) study the concept of noncooperation in the AI context, by

which employees develop new ways of engaging in psychological, social, temporal, or physical niches in their workplace to avoid algorithmic control. The authors discuss the opportunistic notions of foot-dragging, gaming the system, open critique, and leveraging or bypassing algorithms to resist control, which speak to the blockchain's new forms of opportunism regarding algorithm tricking, validator persuasion, and off-chain foregoing. Despite their potential to yield similar outcomes, AI and blockchain are characterized by different technological attributes, with AI being a probabilistic technology and blockchain a deterministic one. Especially in governance context, where control and certainty are paramount, blockchains have the potential to cultivate stability and predictability—an aspect that probabilistic AI models inherently lack.

6.1 Blockchains inside organizations: Avenues for future research

We recommend several important avenues for future research that connect fundamental concepts in the organization literature and the recent phenomenon of the use of blockchains for internal purposes. Even though our theory focuses most prominently on the organizational level of inquiry, we see clear implications for related issues at the individual and group levels. Specifically, the network perspective that we propose on the organizational level can similarly be used at all other levels (individual, group), meaning that multiple units of analysis are theoretically compatible when studying blockchains:

(1) Individuals

Blockchains as a superseding role:

- What are the factors that determine the suitability of human tasks for blockchain governance?
- What are the implications of blockchain governance for task performance and outcomes?

Blockchains as an incentive scheme:

- How do intraorganizational blockchains enable agents to monitor whether principals honor their incentive agreements?

Blockchains as a breeding ground for new forms of opportunism:

- How do intraorganizational blockchains entice employees to engage in new forms of opportunism (e.g., algorithm tricking, validator persuasion, off-chain foregoing) that pose threats for principal monitoring?

(2) Teams

Blockchains for team organizing:

- How do intraorganizational blockchains influence the dynamics of lateral team relationships?

Blockchains for interteam coordination:

- When and why do blockchains improve interteam coordination?
- How do blockchains complement or substitute for the roles of lateral and hierarchical authority?

Blockchains for team performance:

- Under which conditions do intraorganizational blockchains improve team performance?

(3) Organizations

Blockchains and organization design:

- How do intraorganizational blockchains change the design of organizations?

Blockchains and stakeholder transparency:

- To what extent do intraorganizational blockchains prevent potential negative societal effects (e.g., insider trading, top management scandals, structural exclusions) that result from a lack of stakeholder transparency?

Blockchains and information processing:

- Under what circumstances do blockchains complement and substitute for managerial experience and intuition?
- How do blockchains as information structuring tools and artificial intelligence as information processing tools influence strategic decision-making in firms?

Future research could leverage this conceptual framework through various empirical methods. To study the impact of intraorganizational blockchains

on the relationship between principals and agents, researchers can use experimental research methods to understand the behavioral patterns, responses, and changes of employees who use blockchains in their work flows compared to a control group that does not use blockchains. Such experiments may shed light on the technostress that blockchains create (e.g., cognitive load) in contrast to the value that they add (e.g., efficient routines). Additionally, researchers can use blockchain transaction data within organizations to track the flow of information. This analysis can provide insights into the patterns of information distribution, sequencing, and access on the blockchain, as well as identify potential issues or conflicts that arise. By combining qualitative and quantitative data, researchers can gain a comprehensive understanding of the effects of intraorganizational blockchains on governance and organizational design.

Overall, my business plan offers a new perspective on governance in the algorithmic age. We show how blockchains are a valuable tool that allows managers to make organizational processes more transparent and secure, which has implications for both organizational structures and for an organization's relationship with its stakeholders. Hence, we view my paper as a starting point for a fruitful debate concerning blockchains as forms of organizational knowledge engineering, with ample opportunity to connect with various academic conversations in the field of management.

7. Finance and Fundraising

The initial step in my finance plan involves identifying and allocating funds for the adoption of blockchain technology. This encompasses costs associated with development, training, and integration into existing systems. External funding sources, including venture capital and government grants, are explored, emphasizing the potential return on investment and long-term financial benefits. Revenue generation strategies, such as offering blockchain solutions as services or licensing applications, are considered to sustain ongoing financial support.

In the realm of fundraising, my research identifies key avenues to secure funding for blockchain-related initiatives. Research grants from government agencies, foundations, and industry associations are pursued through meticulous proposal development. Collaborative research efforts with academic institutions and industry partners are explored to leverage shared resources and expertise. Crowdfunding campaigns, targeting a broader audience interested in blockchain's organizational impact, are initiated, accompanied by transparent communication of research goals and significance. Corporate sponsorship, particularly from entities aligned with blockchain interests, is sought through comprehensive sponsorship packages.

By addressing the financial implications and securing adequate funding through diverse channels, organizations can navigate the transformative potential of blockchain technology. The significance of these strategies is underscored by the profound ways in which blockchain can mitigate principal-agent problems and influence organizational design, contributing valuable insights to the evolving landscape of organizational governance.

8. Conclusion

My study delves into the transformative potential of intraorganizational blockchains, emphasizing their impact on the principal-agent relationship and organizational structures. By adopting an agency theory perspective, we unravel how the unique governance mechanisms of blockchains address information challenges—concentration, continuity, and conflict—within hierarchical settings.

The coexistence of permissionless and permissioned blockchains on the governance landscape signifies the versatility of this technology. Permissionless blockchains, fostering radical decentralization, offer anonymity and unrestricted access, challenging traditional hierarchical structures. Conversely, permissioned blockchains excel in regulating interorganizational relationships, optimizing supply chain management, and preserving data security. The pervasive adoption of blockchains, with 81 out of the largest 100 publicly traded companies embracing this technology, underscores its relevance and applicability across diverse domains.

Despite the burgeoning interest in blockchain governance, the intraorganizational dimension remains a relatively unexplored frontier. Our

research responds to this gap by advocating for a nuanced examination of how blockchains integrate within hierarchical organizations. This investigation becomes pivotal in light of the inherent clash between the decentralized nature of blockchains and the centralized structure of traditional hierarchies.

Drawing on agency theory, we position blockchains as algorithmic forms of process control, capable of mitigating information asymmetries and providing transparent and decentralized alternatives to hierarchy-based controls. The introduction of blockchains initiates a reconfiguration of organizational dynamics, manifesting as both direct and sequenced information channels among principals and agents. This, in turn, triggers a transformation in organizational design through vertical disintermediation and lateral reintermediation.

My contributions extend beyond the theoretical realm, offering practical insights into the microlevel implications of intraorganizational blockchain governance. We scrutinize the role redefinition of intermediaries, such as middle managers, within this digital governance context. Furthermore, we underscore how blockchains reshape organizational structures by facilitating direct information chains between principals and agents, thereby reducing reliance on traditional information aggregators.

In essence, my paper advances the discourse on blockchain governance, elucidating its impact on information flow, organizational dynamics, and design. By deepening the understanding of decentralized technologies' role within firms, particularly in intraorganizational contexts, we contribute to enhancing accountability, transparency, and trust while navigating the complexities of hierarchical organizing.

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Initiating Data Network Effects: Addressing the Cold-Start Challenge in Emerging AI Strategy

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1. Abstract

While many artificial intelligence (AI) strategies are successful, countless others fail. Why do some strategies succeed while others fail? We adopt a network effects (NEs) perspective to conceptualize AI strategies, highlighting the AI context's specifics. We argue that nascent AI strategies' success depends on data NEs: companies establishing a functional "running system" to capitalize on these effects. However, this presents a challenge known as the cold-start problem (CSP), which involves initiating and accelerating a virtuous cycle: more data benefits the AI system, enhancing performance, which then attracts more data. In this paper, we examine the CSP in nascent AI strategy, exploring how it can be understood in terms of its technological and business dimensions and ultimately be overcome to kick-start a virtuous cycle of data NEs. By drawing insights from existing literature and practitioner interviews, we present a research agenda to encourage further investigation into overcoming the CSP.

2. Introduction

Both academic (e.g., Agrawal et al., 2018, Berente et al., 2021) and industry (Bughin et al., 2018, Ransbotham et al., 2022) research highlights the economic and organizational benefits of artificial intelligence (AI). Investigators increasingly understand the reasons for these advances in terms of network effects (NEs) (e.g., Clough and Wu, 2022, Gregory et al., 2021, Haftor et al., 2021), which provide exponential benefits from increased data volume and representativeness, known as data NEs. The acquisition of more data by an organization leads to increased value creation for both the organization and its customers, enabling increased data inflows to fuel a virtuous cycle. Thereby, value refers to utility—both for members of the organization and for customers, collectively referred to as "users"—which in turn can increase effectiveness or be monetized.

Data NEs can help explain the benefits of AI and the emergence of winner-take-all dynamics in AI markets (Brynjolfsson & McAfee, 2014). They may also offer a basis upon which to understand—and overcome—early-stage hurdles as part of a larger AI implementation strategy relating to the application of AI technologies. We refer to this early and preparatory period as the nascent AI strategy phase. During this phase, overcoming the cold-start problem (CSP)1—that is, a company's inability to obtain data of sufficient quality and quantity to allow for the mobilization of additional data to spur data NEs (often by attracting a sufficiently large user base; Lam et al., 2008)—is a necessary precondition for subsequent AI-led value creation.

The difficulty in establishing data NEs is evident in two recent and well-documented failed cases. First, attempts to build machine learning–based predictive tools to help diagnose COVID-19 during the pandemic failed from a combination of a lack of early access to pandemic data and unclear assumptions about the data (Heaven, 2021). The second example is Amazon.com's attempt to use AI for recruitment, which failed as a result of inadequate data, leading to biased and discriminating outcomes (Dastin, 2018).

Understanding the CSP and how (if at all) it can be overcome can help explain why, even though more than 80% of Fortune 500 chief executive officers indicate that AI will be extremely critical for their business (Murry, 2017), only one in 10 organizations reports significant financial benefits from an AI strategy (Ransbotham et al., 2022) (i.e., by adopting and implementing AI in value creation2), and relatively few companies have adopted AI so far (Acemoglu et al., 2022). Overcoming the CSP is necessary for companies to initiate the virtuous cycles for which data NEs have become known (Hagiu & Wright, 2020). Thus, the nascent stage of an AI strategy is crucial for

organizational performance. We aim to investigate AI as a technology capable of learning autonomously by asking the following questions: What is the role of data NEs in nascent AI strategy? How can data NEs help explain the prevalent CSP? And how can companies overcome the CSP?

We draw from literature on information systems, strategic management, and marketing to provide insights into the managerial challenges of AI strategy, develop a network perspective on AI-led value creation, and analyze the technological and business dimensions of the CSP in nascent AI strategy. We further illustrate these points with insights from interviews with experts in AI strategy.

We contribute in three ways to the emerging literature on AI in organizations and particularly knowledge engineering, a focal subfield of AI that attempts to mimic the judgment and behavior of human experts (e.g., Csaszar & Steinberger, 2022). First, we extend prior research that links NEs to the AI strategy context (e.g., Gregory et al., 2021). We consider AI's characteristics and identify focal peculiarities of data NEs. Second, we extend the current understanding of the CSP to include both technological (i.e., literature on recommender systems and information systems literature in general) and business (i.e., data NEs and theory on NEs and AI-led value creation) dimensions, which is appropriate for this complex interplay between humans and technology (e.g., Berente et al., 2021). We identify approaches to overcome the CSP associated with nascent AI strategy. Third, to the best of our knowledge, no multidisciplinary discussion of nascent AI strategy exists. Such a perspective is necessary, considering that AI strategy is multidisciplinary in nature. We therefore provide an agenda to encourage research in various domains related to this important and rapidly expanding topic.

3. Market Analysis

Drawing from current literature, we characterize AI as an evolving generation of technologies that collect and interpret data from the environment, generate results, and evaluate the outcomes for autonomous learning, interaction, and problem-solving. AI's applications are diverse, and its potential for recombination has positioned it as a general-purpose technology (i.e., AI can not only be repurposed in multiple industries but also be reused extensively, leading to recognizable spillover effects) (Berente et al., 2021, Raisch and Krakowski, 2021).

AI enables process automation, handles complex games, analyzes structured and unstructured data, generates images, and predicts and mimics human language. Importantly, not only are AI-enabled technologies capable of autonomous learning, but their cognitive tasks, processes, and outcomes are also less scrutable, representing a significant departure from traditional information technologies (e.g., Berente et al., 2021, Krakowski et al., 2023).

Crucially, AI's ability to learn and act autonomously in decision-making distinguishes it from other digital technologies with limited autonomy (e.g., Berente et al., 2021). While digital technologies shape how and whether—by human or algorithm—processes occur, they happen in concert with human activities. AI, by contrast, iterates autonomously through a "capability to take what [it has] learned and use it to autonomously make decisions, synthesize information, and structure workflows and other processes" (Tang et al., 2022, p. 1022). The rapid advancements in AI have raised concerns about potential risks to society and humanity itself (Future of Life Institute, 2023).

AI is anticipated to have a profound impact on white-collar workers, as it can perform cognitive tasks previously carried out by humans. Unlike previous technologies that primarily automated manual labor (Brynjolfsson & McAfee, 2014), AI has the potential to automate organizational tasks and processes, augment human work, and even replace workers entirely in some industries, altering the nature of work throughout the economy (e.g., Dixon et al., 2021, Raisch and Krakowski, 2021).

AI has changed organizational strategy and value creation rapidly as a result of increasing computational power at lower costs (Moore's law), refined algorithms (e.g., backpropagation, transformers), and the abundance of large-scale data (e.g., from sensors and cell phones). To gain competitive advantages, organizations strive to acquire data and leverage AI, for instance, to better

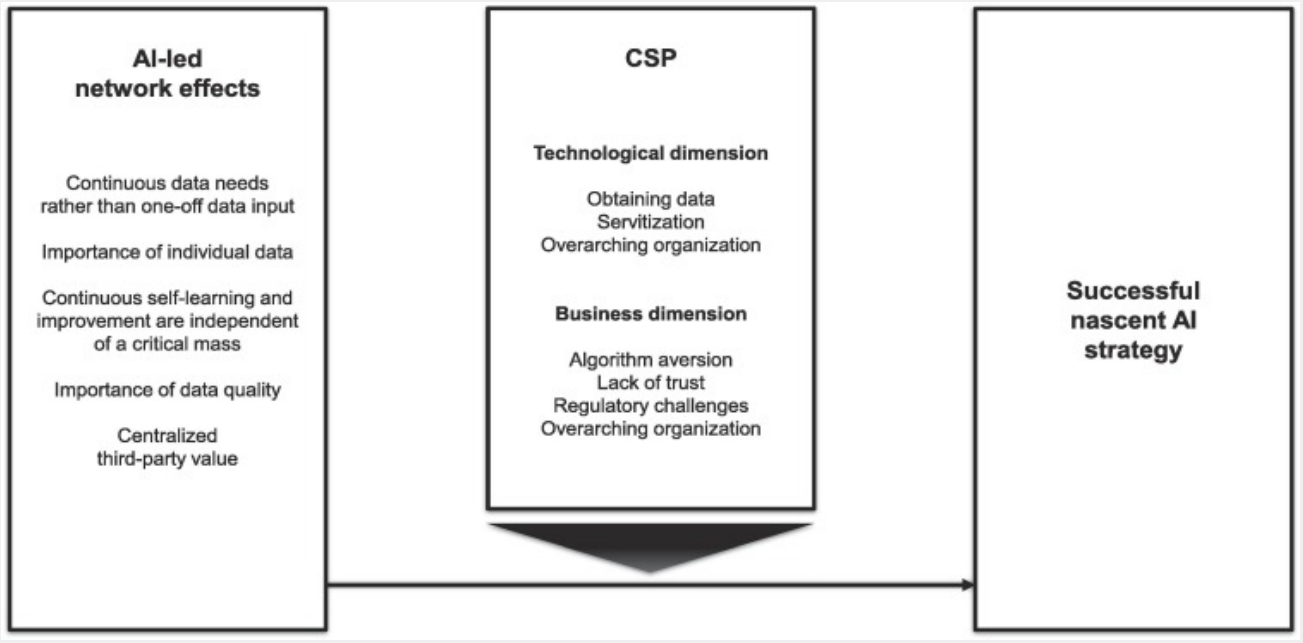

Fig. 1. Conceptual framework.

predict customer needs, automate sales processes, and enhance new product development. However, these potentially positive effects of AI hinge on the realization of NEs. In addition, companies must manage the CSP, which inhibits the establishment of NEs. Fig. 1 provides an overview of our conceptual framework.

4. Competitive Analysis

We build on prior work (e.g., Gregory et al., 2021, Van Alstyne et al., 2016) to explore AI-led value creation from an NEs perspective. This perspective implies that data-driven learning and NEs share a common conceptual framework and give rise to similar economic mechanisms (Clough & Wu, 2022). However, our conceptualization offers several essential distinctions from the original perspective. This elucidation is essential because NEs theory, in its current state, falls short of incorporating the distinct aspects of AI and thus cannot fully explain how users derive value from and contribute value to AI-based systems. While prior research recognizes the critical role of data input for value creation through AI (e.g., Gregory et al., 2021), questions remain about the characteristics of this input. What data sources (e.g., own vs. others' data) provide value to users, and how? Can data value be accurately assessed a priori? Does its value change over time?

Data NEs focus on creating networked value for users, where the utility derived from a platform is determined by the total number of users (Gregory et al., 2021). We consider both organizational and individual users, remaining agnostic about the specific definition of value for these user groups (for a discussion of value creation and subjective value realization by target users, see Lepak et al., 2007). Moreover, we acknowledge that data NEs do not guarantee (or are even the only way) to enable AI-led value creation (for an in-depth discussion, see Knee, 2021).

4.1 NEs theory

Literature typically distinguishes between direct NEs and indirect NEs. Through direct NEs, additional actors (typically users adopting new technology) immediately influence the perceived network value to an individual (Eisenmann et al., 2006, Katz and Shapiro, 1985). For example, the more members join a social network, the more opportunities they have to interact with each other, and the greater is the network's value to each member.

Through indirect NEs, additional users trigger supply-side activities, which then increase the network's value to users (Katz & Shapiro, 1994). For example, in the context of video gaming, a larger installed base of game console adopters induces content producers to increase software supply for the console (e.g., Clements & Ohashi, 2005). The greater availability of games in turn drives demand for the console.

Recent research proposes a third NEs category termed "data NEs" (Gregory et al., 2021): the more an algorithm learns from the data it collects, the more valuable the offering becomes to each user, yielding a positive feedback loop. Theoretical debate is ongoing about whether data NEs constitute a unique category and whether established NEs theory still applies in this regard (Clough & Wu, 2022). Furthermore, data NEs may not necessarily result in positive feedback loops and could even be subject to opportunistic firm behavior, eventually hurting value creation for users (Clough & Wu, 2022). We build on these arguments and add to the debate by detailing the conceptual underpinnings of data NEs vis-à-vis established NEs, presenting the necessary groundwork for understanding AI-led value creation. We argue that data NEs generally conform to the laws of (indirect) NEs theory but possess unique characteristics, which we explicate next.

4.2 AI-led value creation and NEs theory

The fundamental NEs mechanism relevant to AI is simple: more users of an AI-enabled product or service increase the technology's performance, leading to "superior functionalities of the products…, a more personalized and meaningful experience for each user, or other aspects of … quality" (Gregory et al., 2021, p. 536). Thus, value to a user should generally be a function of network size (Hagiu and Wright, 2021, Katz and Shapiro, 1985), if two conditions are met (Cennamo, 2020, Gregory et al., 2022). Additional data from one user benefits all other users, and benefits arise concurrently, not prospectively. For example, the more visitors interact with a website, the more (and likely more representative) behavioral data they generate, which increases the relevance of, for instance, product recommendations for each visitor, driving further visits in a virtuous cycle.

Arguably, data for training AI may also stem from external sources, decoupling the installed base of users to some degree from AI-led value creation (Clough & Wu, 2022). For example, generative AI can be trained on and learn autonomously from publicly available data sources (e.g., large language models [LLMs]). However, although such models are pre-trained on public data, they rely on user interactions to improve further. The use of publicly available data is one way to tackle the CSP, but it only works if the kick-start is sufficient to mobilize further engagement. Moreover, a great deal of data are still private,3 and such data are often (at least in part) necessary to generate AI-led value for companies: companies need to calibrate consumer recommendation engines to their products, and cross- and up-selling decision support systems require input from companies' existing client base. Other examples are chatbots that access product-specific problem solutions or next-best-action systems that recommend messages and channels to optimize customer communications.

Data NEs are inherently indirect and adhere to the mechanisms proposed in indirect NEs theory. Additional users do not by themselves enhance the technology's value to other users by creating more interaction nodes (in contrast with social networks or communication technology; Katz & Shapiro, 1985); instead, they enable the algorithm, considered a "third party" in NEs terminology, to act on network growth with learning. With an increasing amount of data that is representative and of sufficient quality, the algorithm can create superior value for the technology's users, prompting them to disclose additional data and attracting more users, leading to further improvements and, thus, more value creation.

4.3 Unique dimensions of data NEs

We propose five key dimensions that characterize the unique way algorithms leverage NEs mechanisms to create user value: continuous data needs, importance of individual data, continuous autonomous learning and improvement, input variation in usefulness, and centralized third-party value. These dimensions not only demonstrate how AI creates value but also shed light on the challenges associated with enabling NEs in the early stages. We draw on these dimensions to further clarify the CSP.

Unlike the static concept of adoption in indirect NEs theory (Song et al., 2018), data NEs rely on use intensity: users' ongoing disclosure of information. AI-led value creation thrives on a continuous information flow to enhance algorithmic predictions. In addition, as the value of data diminishes over time from environmental changes (which is associated with the degradation of

algorithm functionality), acquiring new data becomes essential to sustain performance.

While users stand at the center of indirect NEs, their incremental contribution to the value created through positive feedback loops is negligible. Indirect NEs are inherently a macro-concept; an anonymous volume of adopters drives the value of a platform for an individual user.

In data NEs, the individual user's contribution to prediction quality is far more significant than indirect NEs theory would suggest. Algorithms typically use two types of information to generate individual predictions: aggregate information from other users (i.e., across-user learning; Hagiu & Wright, 2021) and information from the focal user (i.e., within-user learning). Here, individual user behavior directly and noticeably affects the value derived from an algorithm (Gregory et al., 2021). For example, the quality of Netflix's personalized recommendations requires the focal individual's viewing data. Similarly, AI-derived recommendations on improving a salesperson's selling approach largely benefit from that focal employee's data. Prediction quality hinges on the data a particular user contributes, as the algorithm combines what it knows about the individual user with what it knows about other users. Yet the network remains of vital importance; without it, individual predictions are rendered impossible.

Indirect NEs theory suggests that a critical mass of adopters is necessary to attract complementary producers (Clements & Ohashi, 2005). Through these producers, the platform gains traction. Thus, their commercial considerations of the attractiveness of a market drive indirect NEs, representing a value-creation potential.

By contrast, algorithms steadily enhance prediction accuracy and speed depending on the availability of data points (Gregory et al., 2021), combining data from users to enable and refine their predictions (Cennamo, 2020). A discrete tipping point for third parties to provide value-add does not exist. Thus, market actors' commercial considerations do not influence the beneficial returns to AI-led value creation; rather, ongoing data input and organization-specific learning capabilities are essential.

Established indirect NEs are symmetric in user input because of their macro focus: the characteristics of new network participants are inconsequential, as each new adopter contributes to the "installed base," stimulating the production of complementary goods. However, this principle only partially applies to data NEs. Algorithms rely on data that are of sufficient quality (i.e., adequately representative, diverse, and up to date). Consequently, additional data points can vary in their utility and may even hinder value creation. For example, in automated hiring processes, algorithms lacking a diverse and accurate training database may perpetuate and magnify existing human biases when evaluating employees with diverse backgrounds (e.g., Raisch & Krakowski, 2021).

Relatedly, unreliable data in the form of inauthentic, exceptional, or incomplete input may preclude extrapolation in general and exploratory and inductive insights in particular. Such data may come from users "gaming" the system (Möhlmann et al., 2021) or from competitors' adversarial actions intended to disturb a company's AI-enabled technology. Thus, data quality and composition matter to realize their predictive potential for data NEs.

Theory posits that indirect NEs emerge from the participation of multiple companies, referred to as third parties. For example, various complementary producers, such as game publishers, contribute to the economic success of a platform by developing various games for a game console (Wiegand et al., 2023). However, in the context of AI, a small number of large companies, such as Salesforce's "Einstein" customer relationship management system, and specialized start-ups, such as Celonis, dominate algorithm development. While this centralization of AI development can yield high efficiency, it also exposes vulnerabilities to opportunistic organizational behavior (Clough & Wu, 2022). As a case in point, in the context of pricing algorithms, NEs between companies could lead to algorithmic pricing collusion (Hansen et al., 2021). As a result, the realization of positive

Table 1. Unique dimensions of data NEs.

Dimension	Value creation through established indirect NEs	Value creation through data NEs
Continuous data needs	One-off platform adoption	Continuous use for data input
Importance of individual data	Marginal individual contribution and generic complements (e.g., software)	Crucial individual contribution and personalized output
Continuous autonomous learning and improvement	Critical mass as a potential tipping point for economic actors	Autonomous learning as a technical certainty, with the critical mass as a moving target
Input variation in usefulness	Symmetric effects of input (i.e., each adopter has the same marginal impact)	Asymmetric effects of input (i.e., data representativeness, diversity, and timeliness are important)
Centralized third-party value	Many complementary producers responsible for value creation	A few companies responsible for value creation

Table 1. Unique dimensions of data NEs.

feedback loops hinge on strategic choices in AI development.

Having identified how data NEs create value (summarized in Table 1), we now link these elements to the CSP. Companies need a "running system" for NEs to unfold (i.e., sufficient data yield accurate predictions and, thus, sufficient user value); however, they likely face a CSP when establishing such a system.

5. Product Design

Existing research on the CSP for indirect NEs documents two dimensions (Eisenmann et al., 2006): complementors and users. Similarly, we identify two CSP dimensions in the context of AI strategy: a technological and a business dimension (e.g., Gregory et al., 2021). We argue that nascent AI strategy, if it aims to capitalize on data NEs, can only succeed if the company jointly resolves the technological and business dimensions of the CSP by addressing challenges in key underlying dyadic and triadic relationships.

Prior research stresses the significance of data dependencies in data NEs, encompassing factors such as data quality and quantity, the relevance of personal data, transparency in AI predictions, and user engagement with the technology (Gregory et al., 2021). These aspects are integral to our discussion on the CSP. Furthermore, we expand this discourse by incorporating the unique dimensions of data NEs identified in section 3.3. Notably, the two dimensions can intersect. For example, if users, who are part of the business dimension of the CSP, refrain from sharing data, they contribute to challenges on the technological dimension.

We illustrate the relationships in Fig. 2 with quotes from interviews that we conducted with AI strategy experts in finance and information technology (55 interviews, conducted between December 2019 and January 2021). The interviewees possessed a blend of technical and business domain knowledge and were actively involved in AI strategy implementation, both in their organizations and as

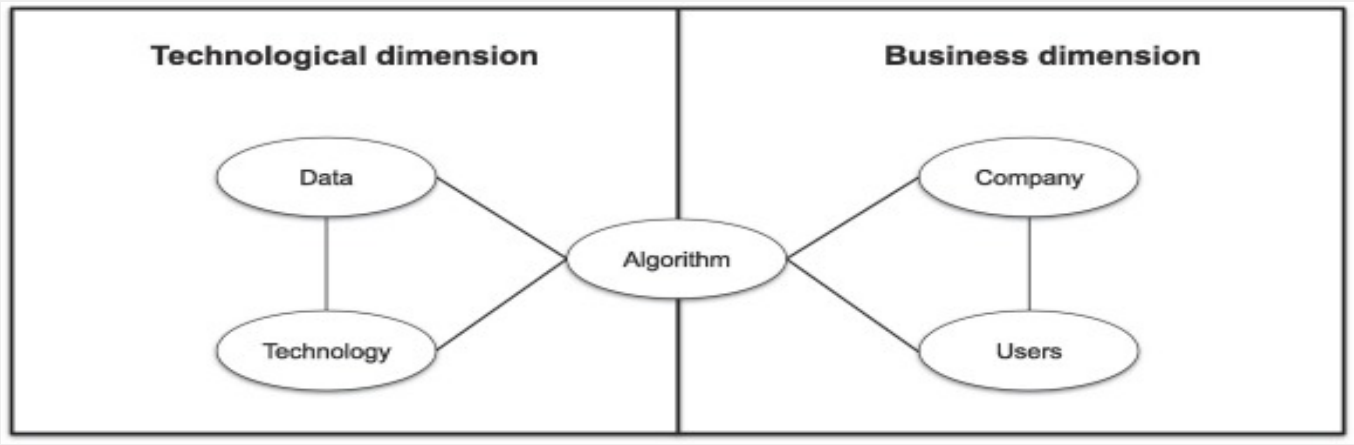

Fig. 2. The CSP's technological and business dimensions.

consultants. While our focus is not on an in-depth examination of these interviews, we reviewed the quotes to establish connections between the challenges the interviewees described and current understanding of data NEs and AI strategy, thus adopting a proof-of-concept approach.

5.1 Technological dimension of the CSP

The technological dimension of the CSP emerges because AI requires both data4 and appropriate technologies: algorithms that parse (and learn from) data, typically cloud technologies that can store large volumes of data, and the hardware required to run AI-mediated processes (e.g., powerful graphics processing units). These prerequisites come with challenges for a nascent AI strategy design. Moreover, regulations shape (and further restrict) the triadic data–technology–algorithm relationship.

Data are a prerequisite when making predictions and deriving insights. Therefore, data quantity and quality are the core requirements to stimulate data NEs (Gregory et al., 2021), improving AI-enabled technologies' output. AI-enabled algorithms will perform poorly if data quality is low or data are incorrect, an issue that interviewees repeatedly emphasized.

One of the big challenges is that we cannot always trust that the data is correct. (Data scientist, tech consultancy)

Moreover, to unfold data NEs, companies must ensure the continuous use of AI-enabled technology. AI-enabled algorithms need continuous access to up-to-date datasets to adjust predictions and improve performance.

To prove that AI works, the client usually wants to have the wow factor. And to show their management that look, we can use … our control datasets…. But to scale it and use AI in your business, you need much more done; you need a plan and structure for getting data. (Data science manager, tech consultancy)

One solution to guide an algorithm in the absence of data is for a designer to stipulate simple rules (e.g., explicit, logic-based rules) for the algorithm to follow (Shaw et al., 2010), which data-driven and autonomous methods can replace or complement over time. In the absence of representative and diverse data, seemingly less invasive data might be sought: simple categorization by the user (e.g., like/dislike decisions for a short list of outcomes; Zhou et al., 2011) or manual tagging of data (Zhang et al., 2010). Using such tools in organizational settings (e.g., identifying a pre-determined set of recommendations through interviews) might also initiate a virtuous cycle in which additional data can be collected and the algorithm improved upon.

Companies can partially address the technological CSP by purchasing pre-trained, off-the-shelf solutions. For example, many of IBM's "Watson" solutions can be applied without further training or calibration. This strategic decision comes with a classic trade-off: while a more open (but less controlled) approach to innovation tends to accelerate innovation (i.e., AI-led insight), a closed approach (with less innovative potential) allows for more control over both the inputs and the outcomes but limits innovation (Boudreau, 2010).

Another pre-trained solution is LLMs (e.g., GPT-4). Such models typically use available data (e.g., public, online) to train a basic model, which then attracts a user base to mobilize additional data, continuously improving the model. An LLM might thus offer a "head start" for general applications. Yet LLMs come with a limitation, as they are not necessarily suitable for specialized tasks, for which they may need further training based on user data.

Moreover, servitization is an ongoing trend: organizations rely on third-party consultants and service providers for AI strategy development and implementation tailored to different user groups in an organization. For example:

We make available an AI workbench … or a framework … for data scientists, data engineers, AI models, to work with, creating … models based on available algorithms and data…. If you're a blackbelt data scientist, that's where you want to be…… But if you want to have a chatbot, you want to train the chatbot on your products and services. Then you won't need [our workbench] because then you would go for one of the off-the-shelf offerings that [company name] and other companies have. (AI evangelist, tech consultancy)

Organizations thus outsource the development of the algorithm and the choice of the underlying hardware to a third party, and they do so in perpetuity—for example, by purchasing software as a service (SaaS) from organizations such as Amazon (Web Services), Google (Cloud), or Microsoft (Azure). While servitization provides a quick solution to the challenge of insufficient data (part of the CSP), there are long-term consequences. The organization becomes dependent on third parties, not only to propose alterations to core processes but also to help implement them strategically.

Finally, regulations set the framework for data and technology usage and thus can contribute to the CSP. Regulation limits which data can be collected, by whom, and under which conditions and thereby can limit the potential of data NEs for AI-led value creation (Gregory et al., 2021).

Examples include data privacy regulations such as the GDPR or the California Consumer Privacy Act. A particular focus has been on the collection and usage of personal data, including IP addresses or cookie identifiers, from users such as customers and employees. Typically, organizations are only allowed to process such data after receiving users' explicit consent and should collect data only for specified and limited purposes (i.e., data minimization) (e.g., Skiera et al., 2022).

The data minimization principle further contributes to the CSP. Organizations are legally obliged to limit data collection to that which they effectively need. However, data minimization contradicts the oftentimes exploratory nature of AI-enabled algorithms and limits data variety that is beneficial to spurring data NEs. Algorithms often give better predictions than theoretical expectations because they identify and test patterns on the basis of data interactions rather than building a model to understand how and why things occur (Leavitt et al. 2021). This exploratory and ex post process renders it almost impossible to predict which data are necessary. An interviewee describes these tensions:

[With] GDPR, you have … data minimization: you should only use what is needed. But when we also know that we need a lot of data to ensure that our applications or algorithms are working well … that's sort of a contradiction. (AI strategist, bank)

Moreover, regulations, including GDPR, but also those likely to be covered in more depth in the proposed AI Act currently under consideration by the European Parliament (2023), require that organizations disclose how they process data and provide an explanation on how their AI-enabled algorithms reach a conclusion. However, AI-enabled algorithms likely offer only "black-box" solutions, as they are typically multilayered, complex, and opaque in how they arrived at a conclusion. Consequently, these regulations contribute further to the CSP by reducing the range of applicable algorithms and, thus, limiting the potential to leverage data NEs (Gregory et al., 2021).

4.2. Business dimension of the CSP

In addition to the technological dimension, the CSP's business dimension has become increasingly important (Fig. 2). Challenges in the dyadic relationships between the algorithm and users (here, customers and employees), as well as the company, have an impact on the CSP. Moreover, the CSP

likely depends on which motivations users infer from the company's AI usage (triadic users–company–algorithm relationship).

User engagement is typically important for data NEs to unfold (Gregory et al., 2021). However, various perspectives, such as the technology acceptance model, appraisal theory, and ethical decision-making theory, provide insights into user hesitance to adopt AI-enabled technologies (for a comprehensive overview, see Habel et al., 2023). In this sub-section, we discuss the role of algorithm aversion and privacy concerns, as they may cause users to disregard recommendations and withhold data from the algorithm, restricting data NEs and fueling the CSP.

First, algorithm aversion refers to humans' tendency to disproportionately rely on their own judgment or on input from other human agents over that of algorithmic agents when making decisions (Burton et al., 2020, Dietvorst et al., 2015). Consequently, users may disregard demonstrably valuable algorithmic recommendations, reducing the potential for AI-enabled machines to learn and improve over time. Algorithm aversion can occur in various contexts, including sales. For example, chatbots closed as many sales as human call center agents when customers were unaware that they were interacting with a chatbot. However, sales dropped by approximately 80% when the organization disclosed that a chatbot made the call (Luo et al., 2021).

Aversion may stem from a confirmation bias, in which users, having experienced a mistake made by an algorithm, believe that all algorithms err (Dietvorst et al., 2015). However, studies have also identified aversion even if no algorithmic error occurs (for an overview, see Chugunova & Sele, 2022). Moreover, the extent of algorithm aversion is context-dependent. For example, aversion is more likely to occur in hedonic contexts (Longoni & Cian, 2022) and when users are less able to understand and affect algorithmic functioning or behavior (Uysal et al., 2022). Finally, aversion may result from the opaque nature of algorithmic recommendations. Algorithms are typically not transparent in how they arrive at a given output, making users less accepting of such opaque recommendations (Kellogg et al., 2020).

Managers can decrease algorithm aversion by allowing users to make (even only minor) adjustments to the algorithm (Dietvorst et al., 2018). Aversion also decreases when humans communicate advice from an AI tool instead of the AI tool directly communicating the advice (Longoni & Cian, 2022). As algorithm aversion likely arises when the algorithm (partly) replaces the decision-maker (Chugunova & Sele, 2022), augmenting human decision-makers with AI instead of (partly) replacing them could pre-empt algorithm aversion (Raisch & Krakowski, 2021).

Second, users may refrain from sharing data or provide inaccurate information out of privacy concerns. When users perceive organizations as excessively collecting data, they may feel a loss of control and ownership over their data, leading to negative affect and behavioral reactance (Puntoni et al., 2021). Consequently, users become less willing to share their data.

Research shows that humans follow a privacy calculus to determine whether to share their data, trading off the associated risks and benefits (e.g., Beke et al., 2022). For example, drivers need to share data on their driving behaviors for usage-based car insurance and thereby risk third parties intercepting their location information for malicious use.

Managers need to be aware of these privacy concerns and help reduce them, for example, by collecting less sensitive data (Beke et al., 2022). Thus, they need to engage in a trade-off between data quality (as sensitive data might be valuable for data NEs) and data access (as users may not provide any data if they have privacy concerns). Additional measures for companies to decrease privacy concerns include granting users increased control over their data, being more transparent about data collection and usage, and working to enhance trust (Bleier et al., 2020).

Regarding the challenges of AI adoption within organizational contexts (e.g., Agrawal et al., 2022), companies' formal (e.g., structures) and informal (e.g., culture) elements can contribute to the CSP. First, a company's formal elements can lower data NEs and thus provoke the CSP. For example,

misalignment between incentive systems (e.g., employees' sales-based variable compensation) and AI-enabled recommendations (e.g., maximizing profits) can cause employees to reject AI technology (Vomberg, 2021). Thus, managers need to align AI-enabled technology with their human resource management approach (e.g., Raisch & Krakowski, 2021) for data NEs to materialize.

Moreover, a company's organizational structure can lead to the CSP (Agrawal et al., 2022). To promote data NEs, AI must have access to various data sources. However, established company structures are widely associated with data silos: data remain in functional areas instead of being shared. Thus, companies frequently struggle to integrate data across sales channels (The CMO Survey, 2022) and particularly between distinct functional domains, reducing the potential to leverage data NEs.

To overcome the CSP, organizations typically need to redefine established workflows. This is to ensure that AI-enabled technology can not only unfold its unique potential but also be optimally integrated into human tasks, augmenting human skills and thus allowing for continued adoption and usage. Such an approach requires the separation of prediction (in which AI-enabled technology is beneficial) and decision-making (in which human judgment is helpful) in workflows (Agrawal et al., 2018) adopting appropriate human–AI decision-making structures depending on contextual requirements (Shrestha et al., 2019). However, such changes may require company-wide transformations (Agrawal et al., 2022), likely redefining departmental boundaries, as a tech consultant elaborated:

If you look at the back-office functions … I think you have to know that you will always need to remove boundaries with the help of technology, but you also risk creating new obstacles and boundaries. (Data science manager, tech consultancy)

Second, regarding informal elements, the prevailing mindset in many organizations is not ideally conducive to successful adoption of AI, thereby contributing to the CSP. Historically, many companies followed a zero-defects paradigm (i.e., error-free processes). However, AI-based predictions likely improve over time and benefit from ongoing experimentation to stimulate data NEs. Thus, AI-enabled technologies require a trial-and-error mentality and failure tolerance (e.g., Tang et al., 2022). One bank employee emphasized:

We come up with different solutions and introduce those to the management, execute management, and then luckily, they support us. So we could share the facts and communicate what could be done, perhaps could be done, and we can have an opportunity to try it out. (AI strategist, bank)

Without a mindset open to perceived failures, employees may be discouraged from relying on AI predictions. Organizations can nurture such open cultures through symbolic acts, such as the "heroic failure award" reportedly humorously handed out by Procter & Gamble (Vomberg et al., 2020).

In addition to dyadic relationships, the user–company–algorithm triad can be a source of the CSP. Whether users will share data with AI-enabled machines may ultimately depend on what motives they infer from the system's use at a more general level (e.g., Venkatesh, 2022). Scant research has thus far evaluated this aspect in the context of AI.

First, employees may fear replacement by technology, referred to as "automation anxiety" (Autor, 2015). For example, "real estate services such as OJO Labs, REX Real Estate, and Roof.ai have replaced human real estate agents with chatbots empowered by AI" (Longoni & Cian, 2022, p. 91). Perceived AI-related replacement threats are common in various occupations (Dixon et al., 2021). As such tools can act and learn without human intervention, they can at least partly replace tasks of which humans had conventionally been in charge (e.g., Luo et al., 2021). Moreover, across-user learning (which characterizes data NEs) may enable employees to replace their co-workers or managers (Dixon et al, 2021). For example, salespeople who share their customer knowledge with AI-enabled customer relationship management systems may risk their co-workers pilfering their customers (Vomberg et al., 2023). One interviewee elaborated:

A lot of people focus on cost-cutting. And of course, it's always appealing to companies to try and do more with less, or the same with less, and people costs are, of course, the big chunk of many

companies' business. (AI evangelist, tech consultancy)

Customers may also respond negatively to AI-enabled technology if they infer that companies installed the technology for cost-cutting—for example, to replace employees (Castelo et al., 2023). Similarly, Uysal et al. (2022) found that consumers perceive AI technology as competing with and replacing human intelligence, reducing their data-sharing willingness.

Second, the adoption of AI technology also raises concerns about surveillance. For example, Uber drivers have reported that Uber's algorithmic management undermines their sovereignty (Möhlmann et al., 2021), and salespeople believe that managers use AI-based technologies to control their daily business activities (Habel et al., 2023). Such concerns can lead to so-called algo-activism, in which users game AI-enabled systems by using them in unintended ways or even manipulating the data (Kellogg et al., 2020, Vomberg et al., 2023); thus, they decrease the value of data NEs and amplify the CSP.

Thus far, research on overcoming the CSP from the user–company–algorithm triad is sparse. One possible solution is a stepwise rollout of AI solutions and the joint evaluation of the technology's effectiveness together with its users (Vomberg, 2021). Thus, we align with other calls for future research to explore this triad (see Kellogg et al., 2020).

6. Marketing Plan

We contribute to the understanding of data NEs and the CSP as a pervasive hurdle in nascent AI strategy. We find that overcoming the CSP is a necessary, but not sufficient, part of successful AI strategy implementation—and ultimately of AI-led value creation. Building on literature from multiple disciplines, we outline five unique dimensions of data NEs. These dimensions help explain how AI technologies create value and identify focal challenges contributing to the CSP. Specifically, we discuss the technological and business dimensions of the CSP and how they intersect to shape and constrain value creation through data NEs.

Data NEs is a burgeoning field of research, and empirical studies of AI-led value creation are sparse. Accordingly, we proceed to offer suggestions for future research. We relate these suggestions to specific aspects of the CSP inherent in data NEs, tying them back to our previously identified strategies for mitigating and managing the challenges.

First, regarding the CSP's technology dimension, more research on the data–algorithm dyad is required. Researchers should explore how organizations can obtain sufficient starting data in quantity and quality. This includes research into new and improved ways of generating data (e.g., synthetic data) to later update them and new ways to meaningfully integrate existing and multimodal data from other fields or applications. Additional relevant questions include the following: how can organizations better engage employees to, for instance, create sufficient starting points? How can companies detect fraudulent and adversarial data?

Second, we call for further research on the technology–algorithm dyad. For example, how can companies get access to technology and use servitization? How can organizations move from pre-trained applications to in-house understanding and development of AI-enabled algorithms? In what situations can servitization be a viable long-term choice, and how should the relationship with the external party be shaped? Moreover, how should organizations be organized to allow for the development of in-house skills and knowledge to code and manage the algorithms themselves?

Third, future research should examine the data–technology–algorithm triad by exploring how regulatory challenges shape the technology-data interrelationships. New AI-enabled algorithms and techniques (e.g., federated learning, edge computing) that meet anonymization and minimization principles should be developed and applied to maximize insights from minimal data collection. Such algorithms should also offer maximum insight and understanding, moving AI away from the current black-box status-quo characterized by opaque and inscrutable algorithms. Moreover, which strategies can companies develop to acquire informed consent from users to leverage their data? In addition to external regulations, which

internal governance mechanisms are necessary? For example, which internal regulations can help prevent other users or organizations from accessing secret or sensitive company data if employees use external AI technology (e.g., LLMs).

Fourth, regarding the CSP's business dimension, we call for further research on the user–algorithm dyad. Psychology-based research should tackle the perceived loss of control when companies rely on user data. Furthermore, scholars should explore which actions managers can take to mindfully overcome algorithm aversion. Relatedly, future research should examine which conditions and reasons spur algorithm aversion and which factors foster the opposite outcome (algorithm appreciation, or the tendency to prefer algorithmic to human advice; Burton et al., 2020), along with contextual and behavioral factors that determine appropriate reliance on the two types of advice. In addition, future research should evaluate the degree of explainable AI necessary to overcome user resistance. Do users require in-depth understanding of how AI reached a focal conclusion? Or do general insights into how an AI-enabled algorithm performs and which goals it aims to achieve suffice?

Fifth, researchers should further explore the company–algorithm dyad. How should companies integrate AI-led value creation at the task or company level. At the task level, managers rely on AI-enabled technology to enhance the precision of decisions that employees currently make (e.g., automating the prediction of customer churn). At the company level, managers may restructure decision processes to fully benefit from AI-enabled predictions (e.g., moving toward algorithmic management) (e.g., Agrawal et al. 2022) or design processes that strike a balance through various hybrid and sequential approaches (Shrestha et al., 2019). Moreover, research is necessary to understand how companies can adjust their formal and informal elements to benefit from AI-led value creation. How do company cultures become open to AI? How can managers make employees see AI as an ally and foster collaboration with it (with AI as a team member or manager)? As change processes need time to unfold, future research should also explore how companies should manage the transition period until returns from data NEs materialize (e.g., identification of milestones).

Sixth, we call for future research on the user–company–algorithm triad. Scholars should explore how managers can communicate AI-enabled technology adoption. Users may perceive AI adoption more favorably if managers emphasize responding to competitive pressures or frame the adoption as an augmentation opportunity for employees to reskill, upskill, and take on new, more rewarding roles with higher added value for themselves as well as the company (Daugherty and Wilson, 2018, Raisch and Krakowski, 2021). Moreover, while employees may fear replacement, AI-enabled machines may also create novel job opportunities (Dixon et al., 2021), which research should explore. Future research should also explore how organizations can prevent users from gaming the system and which leadership styles are effective in adopting AI-led technology. In addition, studies on how serious perceived threats (e.g., threats of replacement and surveillance) are relative to the potential benefits of AI-enabled technology are warranted. Last, as advancements in AI capability seem to evolve at a much faster pace than understanding of exact model functioning, research should investigate regulatory frameworks to ensure safe and ethical implementation of AI systems.

7. Finance and Fundraising

Embarking on a venture in nascent AI strategy necessitates a meticulous approach to financial considerations and adept fundraising. The viability of AI strategies, particularly those centering on data Network Effects (NEs), hinges on surmounting challenges like the Cold-Start Problem (CSP). Within the financial realm, careful budgeting is imperative, encompassing provisions for technology and infrastructure acquisition, human resources, and ongoing research and development efforts.

Allocating funds for cutting-edge AI technologies and securing skilled professionals becomes paramount. Furthermore, fundraising strategies need to be astutely tailored. Identifying potential venture capital firms and angel investors attuned to the nuances of AI, and elucidating the distinct elements of the nascent AI strategy, particularly the potential for data NEs, is critical. Exploring government grants and subsidies, fostering collaborative partnerships, and harnessing crowdfunding platforms can diversify funding sources. Addressing

challenges head-on is crucial in the fundraising pitch, particularly outlining strategies to mitigate the CSP, managing risks associated with data quality, and emphasizing a clear pathway to long-term sustainability.

Establishing measurable Key Performance Indicators (KPIs) and transparent communication channels for reporting progress enhances investor confidence. In navigating the financial landscape of AI strategy, a comprehensive and strategic approach lays the foundation for sustained success and growth in the dynamic field of artificial intelligence.

8. Conclusion

We argue that the success of nascent AI-led strategies crucially hinges on data NEs and that these differ qualitatively from established conceptualizations of NEs in important ways. As data NEs are subject to the CSP, we also show how the CSP's technological and business dimensions can jointly prevent the realization of virtuous cycles associated with data NEs. We hope that our discussion and research agenda spark further work on ways to overcome the CSP and to allow for the emergence of data NEs, which in turn will enable organizations to move from a nascent AI strategy to AI-led value creation.

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Navigating Market Entry Barriers Through Data Network Effects: A Machine Learning Case Study of a Startup's Journey

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1. Abstract

Highly valued firms exploit machine learning to activate data network effects. Data is gathered and analyzed to generate predictions and recommendations. This loop locks in existing service users and locks out potential competitors, thus creating a sizeable entry barrier, particularly for small and medium-sized (SME) enterprises. The literature does not describe the possible pathways to enter markets protected by incumbents' data network effects. This study examines an SME that successfully entered such a market. A key finding is that, for successful market entry, an SME can focus on different stakeholders from those that are targeted by incumbents, provided such stakeholders can legitimize the SME's use of user data generated by incumbents.

2. Introduction

The prediction of demand is one of the most important bases for enterprise decision-making and planning, which is important to reduce risks and avoid blindness.

The smartphone application Waze provides turn-by-turn navigation recommendations that are sensitive to existing and emerging traffic situations. This service offers recommendations for the fastest routes, which might not be the shortest. The app has a large community of users, who are continuously and automatically sharing their spatial and temporal travel data and who also provide data on situations such as traffic jams and accidents. That data, together with historical data and other kinds of data such as weather conditions, enables Waze to use various machine learning techniques (Agrawal et al., 2018, Collins et al., 2021, Finlay, 2017) to identify patterns. These patterns are then used to produce predictions and offer recommendations for the most efficient travel routes. Demand forecasting is one of the most important bases for business decision-making and planning, which is important to reduce risk and prevent blindness (Lin, Lin, & Wang, 2022). The superior accuracy of recommendations by Waze has made it so popular that it has retained its current users while attracting many new users. This growth in its user base has enabled Waze to generate even more travel data, which is used to update the accuracy of its predictions and thus its route recommendations. This self-reinforcing positive learning loop is an example of a data network effect. Network integration is an essential determinant of business innovation, but the mechanism of its impact on innovation performance remains unclear (Boxu, Xingguang, & Kou, 2022). Such a data network effect must be distinguished from a conventional network effect, which depends on the size of the network (Gregory, Henfridsson, Kaganer, & Kyriakou, 2021). Once a firm has activated data network effects, its services will improve thanks to the user data it collects. Thus, it becomes difficult, if not impossible, for competitors to enter the market or remain relevant. As if to reinforce this idea, Google acquired Waze for nearly 1 billion USD in 2013 after Waze had been in operation for five years (Kerr, 2013). The activation of data network effects has contributed to the growth of several other well-known firms at a pace and magnitude never seen before (Parker, Van Alstyne, & Choudary, 2016). Examples include Google's search engine, Amazon's recommendations of products to customers, and Facebook's matching of ads with members' profiles.

When a pioneering firm establishes user services and gradually activates network effects, the users of

those services are reluctant to migrate to alternative service providers because of the excellent service quality they receive based on the superior predictions enabled by large, unique sets of data. This lock-in of users is associated with the pioneering firm's acquisition of a large set of user data that new entrants lack and will be unlikely to generate themselves as long as users remain locked in to the pioneering firm's services. Well-activated data network effects therefore serve as a strong market entry barrier. Furthermore successful leadership in digital transformations are supported by the global attitude and mentality of the leader (Tagscherer & Carbon, 2023).

Bypassing such an entry barrier is even more challenging for a small and medium-sized enterprise (SME). In general, SMEs have become prominent in the sustainable development agenda due to their contribution to promoting economic growth, employment generation and poverty reduction (Karmaker, Al Aziz, Palit, & Bari, 2022). SME managers may be wary of innovations due to the financial costs of adopting innovative technologies (Abbasi, Alam, Du, & Huynh, 2021) and the associated uncertainty. Although typical SMEs may have the advantage of an innovation capability unhindered by massive path dependency (Thietart, 2016), they often lack a large enough customer base and positive cash flows, as well as the financial, human, and other resources necessary to compete head-to-head with incumbents (Macpherson et al., 2003, Supyuenyong et al., 2009, Wong and Aspinwall, 2005). Empirical evidence shows that value proposition innovation drives business performance, while value creation and value capture innovation serve as two key vectors in the mechanism (Guo, Guo, & Ma, 2022). Because SMEs have relatively limited resources, their survival depends on their adoption of new technologies (Abbasi et al., 2021). Current theorizations of SME market entry indicate several ways to bypass entry barriers: (a) by pursuing a broader product and market scope that gives rise to superior cost efficiencies, (b) by differentiating products further, thus attracting a customer base, (c) by targeting a market niche where customers are underserved by incumbents, thus expanding the customer base, or (d) by establishing an alliance with an incumbent (Acs, 2006; Arendt, 2008, Demsetz, 1982, Pehrsson, 2009). However, all these forms of bypassing entry barriers are invalidated by incumbents that have already activated strong data network effects.

Theorization of the activation of data network effects is recent (Gregory et al., 2021), so there are no studies of how to bypass such entry barriers. At the same time, key managerial questions arise. For example, is it possible for a start-up to enter a marketplace that is dominated by one or two incumbents that have activated strong data network effects? The market for mobile phone operating systems offers just such a case, with Apple's iOS and Google's Android leading the market. Hence, the following research question is addressed: What pathway can SMEs follow to enter a market with entry barriers that arise from incumbents' data network effects? An entry pathway refers to the sequence of decisions and subsequent actions that enable a firm to enter a market (Terlaak & Kim, 2021). This study's aim is therefore to identify a start-up's successful pathway into a market that incumbents dominate thanks to data network effects.

This question must be answered for at least two reasons. The first is the well-known market dominance of some firms that have activated data network effects (e.g., Amazon, Apple, Google, and Facebook), which regulators wish to deal with to re-establish competition and drive customer value creation (Smyth, 2019). The second is that, despite substantial potential benefits and an annual investment of some 55 billion dollars over the period 2015 to 2020 (Statista, 2021), there has been a slower adoption rate of artificial intelligence (AI) technologies among SMEs (Horváth & Szabó, 2019). In Europe, "75 % of European Union (EU) companies will be using cloud/artificial intelligence (AI)/big data, and more than 90 % of small and medium-sized enterprises (SMEs) should reach at least a basic level of digital intensity by 2030" (Chen, Sun, & Chen, 2022: 1). However, SMEs account for the majority of businesses globally (World Bank, 2020), and they have a latent opportunity to make innovative use of AI technology (Sun, Zhao, & Sun, 2020).

To answer the present research question and thereby contribute to an important body of knowledge, this paper reports the results of a longitudinal exploratory study (Eisenhardt & Graebner, 2007) of

a start-up that provides digital disease management services for hemophiliacs. The start-up used a novel approach to bypass the entry barriers established by large incumbent firms and thereby enter its target market. Through abductive reasoning (Tavory & Timmermans, 2014) that juxtaposes this case with the recently proposed theory of data network effects (Gregory et al., 2021, Kushwaha et al., 2021), this paper identifies a pathway to market entry. This pathway to market entry relies on legitimacy from stakeholders (Freeman, 1984, Freeman et al., 2007) that have the authority to grant access to user data, including data generated by digital services provided by incumbents (Weerakkody, Irani, Kapoor, Sivarajah, & Dwivedi, 2017). In particular, the value proposition describes the organization's production department, as well as customer segments and relationships with a wide variety of stakeholders (Trapp, Kanbach, & Kraus, 2022). The results make several contributions to theory development. The recently proposed theory of data network effects benefits from two developments. First, the theory benefits from expanding the notion of a single human user of services based on machine learning techniques to the notion of multiple, interdependent users, which may be individuals or organizations. Second, user value may be the result of the co-evolutionary unfolding of events, accounting for the temporality and dynamics of data network effects. Third, this study makes a key contribution to the literature on the market entry of SMEs. Specifically, it describes a novel way to bypass incumbents' entry barriers created by activated data network effects. These results have clear implications for firms' data management, business strategy, and business model design, as well as anti-trust policymaking.

The paper continues with a summary of the recently proposed theory of data network effects, which is assumed here to be a source of abductive reasoning. Thereafter, the research methods are detailed, and an account of the investigated firm is provided. This account is followed by a theoretical generalization based on learning from the case. The paper ends with a discussion of the findings and conclusions regarding the contribution of this study, as well as its practical implications and limitations.

3. Marketing Analysis

The recently proposed theory of data network effects (Gregory et al., 2021) serves as the primary lens for the empirical investigation to respond to the present research question. First, however, that theory must be contextualized within the more established theory of network effects. Strategic networks, understood as configurations of interactor ties that are central for value creation (Burt, 1992), include alliances, joint ventures, and long-term buyer–supplier partnerships (Gulati, Nohria, & Zaheer, 2000). A key underlying notion of such networks is that the locus of value creation is within a given strategic network, not necessarily within a single actor such as a firm (Doz and Hamel, 1998, Giusti et al., 2020, Gulati, 1999, Hilmersson and Hilmersson, 2021). Recent advances in the use of digital technology have enabled interactions between actors that were not possible before (Adamides and Karacapilidis, 2020, Dutta and Segev, 1999, Rehm et al., 2017). These technology uses have enabled the activation of network effects as a distinct source of value creation from actor networks.

Scholars and practitioners have known for some time that firms, particularly technology firms, can design their business models to activate network effects. This notion means that an offering's value comes from both the inherent characteristics of the offering (goods or services), which generate value through actual use, and the network of users that use the offering (Economides, 1996, Farrell and Saloner, 1986, Katz and Shapiro, 1985, Liebowitz and Margolis, 1994, Sheremata, 2004). A classic illustration of these effects is the telephone network, where a single telephone network user will generate no network effects and probably no value at all. In contrast, two or more users will generate network effects because the network's value increases with the number of users that the network can link together. That is, the more users of a telephone network there are, the more value it offers its users. The foundational business model of the social media firm Facebook is similar. The more members it has, the more links to other users it can offer and thereby the greater the value it provides (Eisenmann, Parker, & Van Alstyne, 2011).

This direct, or single-sided, network effect contrasts with indirect, or multi-sided, network effects. Indirect network effects occur when value comes

from the volume of interactions between two or more actors involved in the generation of an offering, typically a producer and a consumer. The well-known mobility-as-a-service firm Uber illustrates this notion. The more riders there are in its network, the more drivers will be attracted to offer transport, which will produce income. Moreover, the more drivers there are in the network, the more riders will be attracted because pick-up times will be shorter and fees will fall as drivers' idle time decreases (Boudreau and Jeppesen, 2015, Hagiu, 2015, Rochet and Tirole, 2003). Some of the world's most valuable firms have created wealth by using just such a network effect, at a magnitude and pace never seen before. Notable examples include Alphabet (Google), Amazon, Apple, and Facebook (Parker et al., 2016).

3.1 Data network effects

Enabled by recent advances in digital technologies and their widespread adoption, firms have gathered large sets of data and have used machine learning technology to analyze those data sets (Alter, 2021, Duan et al., 2019). This analysis enables a new kind of network effect, namely data network effects (Gregory et al., 2021). Whereas the core mechanism of direct and indirect network effects is the size of the network (Afuah, 2013), the core mechanism of data network effects is the scale of learning (Gregory et al., 2021).

Machine learning is understood here as the use of computer algorithms (statistical and mathematical optimization) to improve an offering, where data analysis enables such algorithms to produce accurate predictions. The recent theory of data network effects accounts for value creation from the use of machine learning in organizations that succeed in harnessing data network effects (Gregory et al., 2021). This theory holds that a provider of an offering develops a data network effect when there is a loop of recurring activities. Specifically, a provider of an offering collects user data and other relevant data. This data is then analyzed to detect patterns that enable predictions related to the offering. These predictions in turn serve as recommendations for user decisions. The actual decisions and their outcomes are monitored so that new data is collected. This new data helps update the previously identified data patterns and thereby improve the quality of recommendations. This loop then continues to iterate.

The scale of such data-driven learning and improvements creates increased value for users. Having more data enables learning, which gives rise to better predictions and recommendations, which enhances value creation, which drives up the use of the offering, which then enhances learning, and so on (Agrawal et al., 2018, Samuel, 1959). This loop is again illustrated by the route recommendation service Waze (Kela-Madar, 2021). Crucially, Waze collects location-dependent information, such as map data, travel times, and traffic information from users, as well as users' reports of accidents and traffic jams. Based on historical and real-time data on traffic, weather, and other factors, machine learning techniques generate recommendations for routes and offer real-time updates. This setup means that the fastest route may not always be the shortest one at a given time and place. The success of Waze has attracted many users, enabling it to generate large volumes of data. These volumes of data then improve the quality of its route recommendations. Such improvements attract even more users, who generate additional usage data, further improving the quality of predictions, and so on. Accordingly, Waze reflects a provider's capability "to learn from data to continuously improve its products or services for each user" (Gregory et al., 2021: 538). This process drives a user's utility, understood as "a function of the scale of data-driven learning and improvements" made with machine learning (Gregory et al., 2021: 536).

A core question answered by the theory of data network effects is the following: What factors co-condition user value creation from the use of machine learning technology? The answer is that data network effects have a direct positive relationship with a provider's machine learning capability and users' perceived value from the use of the provider's offering (Gregory et al., 2021). The theory further proposes that this relationship is moderated by the provider's legitimation, data stewardship, and user-centric design. Based on the work of Gregory et al. (2021), these co-conditioning factors are briefly summarized because several of them are crucial to understand the present empirical investigation and the subsequent response to the research question at hand.

3.2 Factors that co-condition users' perceived value

Machine learning capability is the core driver of data network effects, which derive from the ability to learn from data and thereby continuously improve offerings for each user. To generate user value, the identified data patterns enable predictions that are the core mechanism for user value creation. Such predictions enable the forecasting of occurrences to produce recommendations for a given decision. Examples of such decisions include film choices, medicine dosages, and credit worthiness. To this end, the speed and accuracy of predictions are regarded by the theory of data network effects as central for users' perceived value. If it takes an hour to recommend a 15-minute route, then users' perceived value will probably be lower than if the time to generate such a recommendation is only a second. Similarly, if the recommendation says that the route requires 15 min when it actually requires two hours, users' perceived value will probably also be low.

The next two co-conditioning factors concern data quality and data quantity. To produce accurate predictions, accurate patterns must be detected in available data sets. This detection of accurate patters in turn requires the right amount and quality of data. The quality and quantity of data depends on the specific application, the algorithmic techniques, and the requirements for user value creation. More generally, however, situations with an insufficient amount and quality of data about a range of cases of the same class must be avoided because they may lead to misinterpretations of new cases that algorithms encounter when used (Agrawal et al., 2018).

The next two co-conditioning factors concern user-centric design, understood as a user's performance expectancy and effort expectancy (Dwivedi, Rana, Janssen, Lal, Williams, & Clement, 2017). Because the quality of predictions is highly conditioned by the quality and quantity of the data sets analyzed for pattern recognition, it is crucial to incentivize potential users to use the offering, which is what generates new data. With this aim, performance expectancy is understood as the extent to which potential users assume that using the offering will enable them to complete the task at hand. Effort expectancy, on the other hand, is the extent to which potential users assume that using the offering will not require substantial effort. Both these factors shape potential users' intentions to use an offering and thereby to create value through usage and generate data for future predictions (Dwivedi, Rana, Jeyaraj, Clement, & Williams, 2019).

The final two factors concern the offering's legitimacy. The provider of an offering needs to secure the positive legitimacy of key stakeholders in order to ensure positive perceptions and therefore usage of an offering. Legitimacy is defined here as an actor's perceptions and assumptions that the decisions and subsequent actions of another actor are appropriate and desirable within a given social sphere of norms (Suchman, 1995). Therefore, if the navigation software Waze collected data on daily travel routes and provided this data to the government intelligence agency without users' acceptance, its users would most probably cease to use Waze. This scenario reflects the personal data use factor of an offering's legitimacy, which is understood as the provider's legitimate collection and use of personal data without violating the formal and informal norms for such data use. The second factor of an offering's legitimacy is prediction explainability, which concerns stakeholders' understanding of an offering with regard to why a recommendation is generated the way it is. A detailed understanding of the underlying mechanism used to generate a recommendation is often not possible due to its complexity (Mayenberger, 2019). However, the general underlying principles of how an offering generates predictions can be disclosed to ensure stakeholders' trust and understanding. For instance, if Waze recommended a route that was longer than the shortest available one but explained that the reason for the recommendation was to enable emergency vehicles to reach their destination faster, then users may find the recommendation appropriate.

Combining all the co-conditioning factors listed here, the theory of data network effects explains that a users' perceived value comes from the machine learning capability of a provider with a level of prediction speed and accuracy that is suitable for the given recommendation. This positive relationship is

strengthened by higher data quality and data quantity, higher performance expectancy, lower effort expectancy, and more legitimate personal data use and prediction explainability. The theory of data network effects offers a unique account of value creation from the use of machine learning technology (Gregory et al., 2021), in contrast with the literature that accounts for value creation from the use of digital technologies in general (Bharadwaj, 2000, Brynjolfsson and Saunders, 2009, Chae et al., 2014). The latter typically black-boxes technology by disregarding its unique characteristics and capabilities (Dwivedi et al., 2015, Orlikowski and Iacono, 2001), whereas the theory of data network effects explicitly accounts for a particular kind of digital technology use, namely machine learning. Despite its merits, this theory was recently criticized for its disregard of value appropriation from activated data network effects based on the use of machine learning (Clough and Wu, 2022, Gregory et al., 2022). Although that criticism is valid, any theory has its limitations, and the theory of data network effects focuses on perceived value creation, not value appropriation.

4. Competitive Analysis

A unique feature of data network effects is that value creation comes from many actors' use of an offering. The accuracy of the recommended travel routes provided by Waze depends on data generated by multiple users, both past and present. Hence, the more users there are, the better the recommendations will be, and the higher users' perceived value will become. By extension, this argument implies that if provider A is first to enter a market with a specific offering that activates data network effects (e.g., recommendations for travel routes, music, or films), then provider A will attract users with its novel offering, assuming that it is relevant to users' needs. As users start to use the new offering, they generate unique data that is crucial for the further improvement of the predictions that are central to that offering. This quality improvement is likely to attract new users and retain existing ones, which generates additional data and thereby enhances the quality of predictions. When provider B wishes to enter the same market with a similar offering, it is at a major disadvantage because it has access to neither historical usage data nor a current user base with real-time usage data. Therefore, the first mover (i.e., provider A) has established a crucial entry barrier for any imitator to enter the market.

A recent example is in the streaming music industry, where Spotify's early entry and rapid growth activated all three kinds of network effects (direct, indirect, and data network effects). Machine learning finds patterns regarding users' music preferences in a given situation (e.g., time, place, and personal profile). Thus, Spotify can recommend a playlist that is more accurate than those recommended by late-entry actors such as Apple Music (Saura, 2021, Towse, 2020). In this sense, Spotify has built an entry barrier to imitators from its activation of data network effects, even though Apple has a significantly larger user base for its total service provision. In the case of large and highly diversified firms, such as Alphabet (Google), Amazon, and Apple, late entry with inferior service provisions can be subsidized by other business lines aimed at providing complementary offerings (Amit & Zott, 2001). Such a strategy aims to make users of the first-entry provider migrate to late-entry providers, attracted by a portfolio of multiple complementary offerings that the first mover does not have. Depending on the specific case, such a strategy may or may not succeed (Watson, Weaven, Perkins, Sardana, & Palmatier, 2018). Because SMEs are typically single-business firms, the strategy of subsidizing through complementarities is not an option. Consequently, SMEs are hindered by entry barriers due to the first mover's data network effects and a lack of resources (Spithoven, Vanhaverbeke, & Roijakkers, 2013). Hence, the research question addressed by this study is as follows: What pathway can SMEs follow to enter a market with entry barriers that arise from incumbents' data network effects?

Because there is no theory explaining how an SME can overcome the entry barriers raised by the activation of data network effects from the use of machine learning technology, epistemological discovery was sought (Locke, 2011) through an abductive research mode (Tavory & Timmermans, 2014). When existing theories cannot account for a given phenomenon (here, entry pathways), a deductive approach may limit inquiry by imposing predefined categories and their relations on the conception of the focal phenomenon. In contrast, a

Table 1. Specification of the study's interviews and interviewees (denoted "stakeholders") from mid-2017 to end of 2021.

Stakeholder	No. of representatives	No. of interviews	Length	
			Mean min.	SD min.
Employees at Alfa (focal firm)	13	164	56	17
Patients	23	41	41	7
Relatives	11	19	22	6
Patient interest organization	6	27	46	9
Hemophilia treatment center	14	57	63	22
Dental and Pharmaceutical Products Benefit Agency	5	21	44	19
Regional agencies	6	18	51	11
Pharmaceutical firm A	2	4	56	3
Pharmaceutical firm B	2	5	46	7
Pharmaceutical firm C	3	8	71	13

Table 1. Specification of the study's interviews and interviewees (denoted "stakeholders") from mid-2017 to end of 2021.

purely inductive mode of inquiry ignores previous knowledge to guide exploration (Behfar & Okhuysen, 2018). Abduction, regarded here as a combination of induction and deduction, aims to avoid the shortcomings of induction and deduction. It does so by allowing for openness to the discovery of new characteristics and relationships, while being able to link discoveries back to some pre-existing body of theory (Tavory & Timmermans, 2014). To this end, an exploratory longitudinal study of a start-up was performed for the purposes of theory building (Eisenhardt & Graebner, 2007). This approach is especially suitable for process questions such as the present research question (Eisenhardt, Graeber, & Sonenhein, 2016). The exploratory characterization of the start-up's path to the marketplace showed that the start-up had successfully provided a novel service that targeted stakeholders overlooked by competitors. Those stakeholders were examined in a dedicated follow-up study. The goal of that study was to confirm stakeholders' satisfaction with the novel services identified in the prior exploration of the entry process. A comprehensive description of that study and its results are detailed in the Appendix A.

The setting was a start-up in the hemophilia healthcare sector in a Nordic country. The data spanned the period 2015 to 2021. This setting was chosen thanks to the opportunity that emerged during another empirical study (Climent & Haftor, 2021), where a professional relationship was developed with a senior manager at one of the studied firms. In 2017, the manager created this start-up, referred to here as "Alfa". Thus, the sampling in this study was both opportunity-driven (Patton, 1990) and theoretically motivated because the characteristics of the studied phenomenon matched the targeted theoretical gap (Eisenhardt & Graebner, 2007).

4.1 Data sources

Alfa's entry process was studied with multiple data sources. Multiple data collection methods were used to gather both qualitative and quantitative data (for the latter, see the Appendix A). Semi-structured interviews were used to interview representatives of the focal firm and other stakeholders. These stakeholders included patients and their relatives, a patient interest organization for hemophilia patients, regional health agencies, the national Dental and

Pharmaceutical Products Beneficiary Agency, the staff at three hemophilia treatment centers, and representatives from three pharmaceutical firms that actively promote hemophilia products. Table 1 provides a summary of the interviewees and interviews. Follow-up emails were sent to gather various details with specific inquiries. Statistics on the sales of hemophilia pharmaceutical products were gathered, together with archival information regarding the market and its regulations and practices, as well as information about hemophilia diseases and treatments.

The interviews at the focal firm targeted all of the company's 13 employees. The informants' historical and current professional profile and role were covered, followed by detailed specifications of the firm's intentions and rationales, as well as the actual activities conducted in relation to those intentions. The interviews typically ended with further inquiry into the items that arose during the interview. Nearly all employees were interviewed multiple times, and several other stakeholders were interviewed. The focus was on both understanding the role of each stakeholder in the entry of the focal firm and triangulating the data from other sources, including the representatives of the focal firm.

Several measures ensured the validity and reliability of the data. The first was the use of multiple sources from both within and outside the focal firm at different levels of the organizational hierarchy. Second, the anonymity of the informants encouraged them to speak with candor. Third, questioning was non-directive. Fourth, event tracking was used to ask informants to give chronological details of key events that had happened and were planned in order to build scenarios. The pharmaceutical industry is highly regulated within the European Union, so each country's dedicated authorities gather detailed data on the real sales and prices of every pharmaceutical product. Such data is freely available upon request. Thus, all market-related data for hemophilia products in the focal Nordic County was obtained.

4.2 Data Analysis

Research database software was used to store the data. One author started by constructing a comprehensive case scenario of the events covering the three phases of the focal firm: pre-establishment, establishment, and market entry. The other author critically reviewed this scenario. When details were missing or unclear, follow-up data gathering provided clarifications. This process was iterated several times. Simultaneously, the other author conducted atheoretical coding of the collected data, followed by grouping into themes. These themes were subsequently critically reviewed by the first author. This process was iterated several times to update the themes. The case scenario was then compared with the themes, which generated insights into the pattern of market entry of the focal firm and its potential underlying logic. Thereafter, this pattern was compared with the theory of data network effects, which involved multiple comparisons that eventually produced an updated pattern. This updated pattern is reflected in the emergent theory presented below (Eisenhardt et al., 2016, Klein and Myers, 1999). In particular, the various actors, along with their interests and actions, were carefully mapped. This mapping enabled identification of a key theoretical anomaly in the case. Detection of this anomaly initiated retroduction back to the assumed theoretical framework. This inquiry in turn led to a resolution and the formulation of the theoretical contribution presented here. Overall, "successful market entry" is used as the dependent variable (Bourreau et al., 2021, Park, 2020).

The empirical case study is presented first in atheoretical mode and then in a theory-generation process that results in new theoretical insights.

4.3 Case Study

The focal firm's local market was healthcare services in the hemophilia products market, specifically a disease management system for hemophiliacs. Between 2005 and 2014, six international pharmaceutical firms introduced novel hemophilia products to the national marketplace. A senior manager at one of these firms spotted a novel business opportunity and left employment in mid-2017 to establish a new firm, Alfa. The aim was to offer a new kind of disease management system that included the use of machine learning technology. The subsequent events that led to Alfa's successful market entry are separated into three phases. The first is pre-establishment, between 2010 and 2017, where the incumbent pharmaceutical firms launched their hemophilia pharmaceuticals,

followed by complementary digital services in the form of smartphone applications. The second phase is establishment, from mid-2017 until early 2019, when Alfa was created and developed its key offering. The third phase is successful market entry from mid-2019 until the end of 2021. During this phase, the firm received a breakthrough contract from regional health agencies. Before detailing these three phases, an introduction to hemophilia is given to provide background on the rationale for Alfa's market entry.

Hemophilia is a rare bleeding disorder in people where a lack of clotting factor causes blood not to clot properly. This lack of clotting factor can cause internal and external bleeding, leading to damage or death if not stopped (Franchini, 2013). Crucially, bleeding may occur both spontaneously and as a result of injury. Internal bleeds are common and typically occur in joints and muscles, although sometimes in the brain. If not stopped rapidly, internal bleeds can cause death or produce swelling and joint destruction (hips, knees, ankles, and shoulders) generating chronic pain and requiring surgery. There are two types of hemophilia: Hemophilia A is caused by low levels of factor VIII, whereas Hemophilia B is caused by low levels of factor IX. Alfa's services focus on Hemophilia A patients because of the larger patient and data volume (Franchini, 2013).

Individuals with moderate and severe hemophilia must be treated with special treatment that infuses or injects replacement clotting factor into a vein. Lifelong treatment with replacement factor is necessary. If done properly, individuals can enjoy a high quality of life, although with an adapted lifestyle. The replacement factor can be provided to hemophiliacs on demand or through prophylaxis. Prophylaxis means that the replacement factor is injected regularly, typically two or three times a week, depending on a number of factors. On-demand treatment is conducted to stop ongoing bleeding. In most developed countries, a prophylaxis-based treatment is pursued for severe and moderate hemophiliacs, accompanied with on-demand treatment when needed to stop ongoing bleeds (Shrestha, Eldar-Lissai, Hou, Lakdawalla, & Batt, 2017). This approach not only reduces the risk of fatality and major injuries but also substantially improves quality of life for hemophiliacs and reduces healthcare costs associated with damages caused by bleeds. The challenges of prophylaxis-based treatment include the need to determine exactly how much replacement factor to provide and when, which depends on a number of aspects. Too little replacement factor still exposes hemophiliacs to great danger, whereas too much drives the treatment costs up. These costs are already high, often on average slightly more than 100,000 Euro per patient per year (Shrestha et al., 2017).

Hemophiliacs are treated at special hemophilia treatment centers (HTCs). These HTCs offer diagnosis and customized lifelong treatment regimes. They have several specialized experts working with each patient: hematologists, dentists, nutritionists, physiotherapists, psychologists, and surgeons. Hemophiliacs are advised to follow a lifestyle that reduces risk and promotes their health in terms of type of work and leisure activities, travel, and dietary practices, as well as their intake of other medication (Lamiani, Bigi, Mancuso, Coppola, & Vegni, 2017).

Table 2 shows the temporality of the introduction of replacement factors and related digital disease management systems by the studied firms. The six pharmaceutical product brands were introduced between 2005 and 2013. Digital disease management systems that did not use machine learning techniques were introduced from 2015 to 2018 aimed at various stakeholders. Machine-learning-based services were introduced between 2019 and 2021. The focal start-up (Alfa) introduced its disease management system, which uses machine learning techniques, in 2020, expanding it in 2021.

Introduction	Year	Patient	Relatives	PIO	HTC	RA	BA	MPA
Digital services: ML-enabled	2021	1, 3, 4, SME	SME	SME	SME	SME	SME	SME
	2020	2, 5				SME		
	2019	6, SME			SME			
Digital services: Not ML-enabled	2018		1, 4	1, 4		5	5	5
	2017	1, 4	2, 5	3, 6	1, 4	2	2	2
	2016	3, 6	2, 5	2, 5	3, 6			
	2015	2, 5			2, 5			
Pharmaceutical products	2014–2005	2005: 1; 2009: 2, 6; 2010: 4; 2012: 3; 2013: 5.						

Table 2. Introduction of pharmaceutical products and related digital disease management systems by hemophilia health providers and the focal firm Alfa.

Between 2005 and 2013, six international firms each introduced a new generation of pharmaceutical products that offered replacement factor for hemophiliacs with Hemophilia A (Table 2). These products are highly similar in terms of their efficacy and safety profiles (Climent & Haftor, 2021). The introduction of such prescription drugs to the market is highly regulated. It starts with medical approval of a given drug by the Medical Products Agency. This approval is followed by product price setting by the Dental and Pharmaceutical Products Benefits Agency because public medical insurance covers most of the costs associated with a citizen's medical healthcare. This price setting by the Dental and Pharmaceutical Products Benefits Agency intends to eliminate price-based competition between pharmaceutical firms, meaning that products that target the same medical indication and that have similar efficacy profiles are assigned similar prices. Direct-to-consumer marketing for prescription-based pharmaceuticals is prohibited in the European Union. Therefore, pharmaceutical firms' key channel to promote their products are sales representatives, who regularly meet with the physicians that prescribe their drugs to detail the product's profile. Prescribers are key gatekeepers because they choose which products to prescribe to patients. However, drug selection is influenced by an official list of recommended drugs for each medical indication. This list is issued by each regional agency. The Nordic country where Alfa is located is geographically and administratively organized into 21 regions. Each region is managed by a regional agency that is responsible for healthcare financing and provision to its citizens. The drug selection process conducted by prescribers may also be influenced by lobbying from a patient interest organization and specific patients and relatives.

In 2015, six pharmaceutical firms shared the market. Two dominant firms had between 27 % and 30 % of the market share, two intermediate firms had 12 % to 15 %, and two lagging firms had 7 % to 9 % (Climent & Haftor, 2021). Because the six firms promoted six similar hemophilia products and price-based and marketing-driven competition was not possible, they launched complementary digital disease management systems in the form of dedicated software applications (apps) for smartphones. At the time of the study, the penetration of the use of smartphones was nearing 100 % of the country's population, and hemophilia patients already kept dairies. In these diaries, patients record their medical history (experience of bleeds: when, where, and why), the use of replacement factor and other medicines, and their lifestyle and nutrition habits, as well as their health status and well-being. These diaries are reported regularly to physicians, who analyze their content to adjust the replacement factor use and other kinds of treatment, as well as lifestyle recommendations.

In 2015, two of the six firms launched their app, with digital services targeting patients and HTC staff. Two other firms followed with a similar launch in 2016. The two pioneers then expanded their digital services toward other stakeholders (relatives and the patient interest organization). The two remaining firms launched their first app in 2017, whereas the other four firms, which had already launched their apps, expanded their digital services toward other stakeholders. Eventually, in 2018, the six firms were offering similar digital services via their apps to the same stakeholders (Table 2).

The content of the digital services provided by these firms can be conceived in terms of the activity chain of a hemophilia patient's disease management. Besides the functionality for (i) user profile registration, they offer functionalities for (ii) diagnosis, prognosis, and treatment profile registration by the HTC, (iii) patient reminders for replacement factor injections at the right time and dosage, as well as reminders for other activities including visits to the HTC, (iv) patients' registration of actual bleeds (where, when, and how much), (v) the actual treatment conducted, such as replacement factor injections (when, where, dosage, and treatment mode in the form of prophylaxis, on-demand, other medications, and measures), (vi) data records of lifestyle, (vii) lifestyle support (dietary recommendations, addresses of pharmacies and HTC centers when traveling, and recommended physical exercise sites), and (viii) customized report generation for HTC staff, patients, and relatives (Climent & Haftor, 2021).

In 2016, one of the six pharmaceutical firms started to develop a recommendation functionality for replacement factor intakes for each individual who used their product. That recommendation functionality was aimed to be provided through the patient app. Patients using this firm's replacement factor registered numerous data points daily. This data was analyzed with machine learning techniques to identify patterns and then derive predictions to generate personalized recommendations for replacement factor intakes in terms of when and how much to inject. The timing and amount of appropriate replacement factor intake is co-conditioned by a number of factors (Aoki et al., 2015, Lopes et al., 2021). These factors include the individual's level of natural coagulation factor and volume and timing of previous intakes, physiological characteristics such as age, body mass, and metabolism, and behavioral factors such as risk profile, dietary and physical exercise habits, and the use of other medications (Franchini, 2013). The aim of the pharmaceutical firm that pioneered this recommendation functionality was to provide patients with more precise recommendations for replacement factor intakes than those that patients made on their own.

For various reasons (technological, medical, regulatory, and administrative) the development of this functionality was heavily delayed, and the pharmaceutical firm did not introduce it until the second half of 2019 (Table 2). One of the senior managers at that firm recognized a market opportunity with the introduction of app-mediated digital disease management system for hemophiliacs. The app should include a function for recommended replacement factor intake. This recommendation would be based on large data sets analyzed with machine learning techniques. Moreover, it would be unlimited to a specific replacement product brand. The idea was to target all hemophiliacs with one disease management system rather than having each firm target the patients who used its specific replacement factor products. As reported by the CEO of Alfa in one of the interviews:

Targeting all patients with one app only in a marketplace potentially allows for a larger user base than each pharmaceutical firm, which targets only its replacement factor users. This larger user base can provide much larger data sets that are important for the quality of predictions and therefore the accuracy of recommendations provided to users.

This CEO had nearly 20 years of experience in marketing and sales in pharmaceutical firms across Nordic countries. In the first half of 2017, the CEO resigned to establish a venture, Alfa, to launch a digital disease management system to hemophiliacs that was independent of any product brand. The CEO secured financial capital from two private investors and employed a family member (daughter), who graduated from engineering school with a master's degree in computational sciences, to develop the machine learning technology. Several software engineers and usability designers were also

recruited, together with a senior key account manager and a senior communication professional, both from the CEO's former pharmaceutical firm. The number of employees grew to 13 in 2021. The initial priority was to develop a prototype and test it, or, as the CEO of Alfa explained:
I believed, and still believe, that a key to success with this business is to develop a superior app, both in terms of its functionality and its usability. And as the existing apps are not that well designed, we have a good chance to succeed with ours.

Within a year, Alfa had developed a full initial version of its app for hemophiliacs. Patient testing started in the second half of 2018, and it was introduced to the market at the beginning of 2019. This market launch was not successful because the initial uptake among patients was very low and stagnated quickly. This outcome came as a surprise, as noted by Alfa's Market Director and head of the market launch:

Well, we clearly underestimated how challenging it is to launch an app of this kind. We only had experience from launching pharmaceutical products.

Alfa conducted a number of in-depth interviews with patients to learn more about their needs with regard to the use of the app. These interviews revealed two kinds of limitations that their digital service would benefit from. One was the user design of the app. The other was the accuracy of recommendations for patients' intake of replacement factor. The user design was relatively uncomplicated for Alfa to improve. However, the improvement of prediction accuracy represented a major challenge because of the lack of data to generate more accurate recommendations. At that time, each pharmaceutical company could access data from patients that used its products, whereas each HTC could access all the data on its patients. There were three HTCs in the country, implying that no single actor could access the data for all patients. Alfa's management (CTO) understood this issue:

To improve the accuracy of our predictions, we needed to access all data available at the three hemophilia treatment centers, but we lacked the power to do so.

The challenge of data access made Alfa radically modify its strategic intentions, from initially targeting patients to targeting regional agencies. The CEO described this shift:

As we realized that regulatory agencies had the power to provide us with all available patient data, we also knew that they hold a keen interest in the actual uses of pharmaceuticals and their costs.

Within three months, Alfa had established close dialogues with the three regional authorities where the country's three HTCs are located. These three authorities had the power to decide on the use of patient data. Alfa's message to them was that if Alfa was provided with data on all hemophiliacs' use of replacement factor, it had the knowledge and technology to analyze the actual use of the replacement factor continuously so as to detect potential suboptimal use of replacement factor. The acquisition and use of knowledge is crucial in the process of enterprise development (Zhao, Wen, Zhou, Liu, Yu & Xu, 2022). This analysis would provide the regional agencies with specific information on unnecessary costs due to overdosages of replacement factor and possible underuse of replacement factor that may cause serious health issues and additional healthcare costs. The more data that was provided and updated, the better the analysis would be at pinpointing potential areas to reduce overuse and underuse of replacement factor. Alfa was successful, thanks to its know-how, as reported by the Section Manager of the regional agency (top) and Alfa's Market Director (bottom):
When they presented the idea to us, it did not take us long to decide to say yes to a test as they clearly had detailed know-how and technology to do the kind of analysis that we are supposed to do but lack capability to do it.

We were rather surprised how quickly the three regional agencies agreed to provide us with all the data to test our service. Initially, we were a bit worried that if we presented the idea to them, they would do the analysis themselves. From our discussions with them, we realized that they do not have that technical capability and that they need us.

After initial tests, Alfa received two-year contracts in 2020 with all but one regional authority in the country. Toward the end of 2021, Alfa succeeded in receiving a similar contract from the national Dental and Pharmaceutical Products Beneficiary Agency. Their interest was to understand the actual dynamics of this type of pharmaceutical use as a foundation for forthcoming price renegotiations with the six pharmaceutical firms that provide the replacement factor. Such renegotiations are common practice every three to five years.

Alfa then updated its recommendation functionality for patients' usage of replacement factor and relaunched its updated patient app in 2021. This update also offered some specific functionalities for patients' relatives, such as parents. This time, its app-mediated services were also provided to and promoted by the hemophiliacs' patient interest organization, which enabled a faster user uptake than with the first launch attempt. Alfa now mainly targeted patients who were new to the use of replacement factor or were switching from one brand to another. Because there were patients who used the same product brand for many years, it would take considerable time before Alfa could gain a large market share of digital services for hemophiliacs.

On the revenue side, Alfa's initial plan was to charge a small subscription fee to patients who used their services. That plan implied that Alfa would need to expand internationally before it could earn enough revenues for a positive financial result. Alfa's broadening of target groups to include regional authorities and the Dental and Pharmaceutical Products Beneficiary Agency, however, provided large enough and stable revenue sources so that Alfa did not need to charge a user subscription fee, which could deter some patients from using the service. Alfa offered its disease management system services to hemophiliacs for free. At the end of this study, in 2021, two of the pharmaceutical firms that were lagging in their digital services provision to patients, announced that they would stop providing such services and would recommend that their patients use Alfa's services, which added a significant volume of users to Alfa's services.

5. Product Design

This section outlines some lessons from the detailed Alfa case and pursues an abductive process of theoretical development. The starting point is theorization on conventional product market strategies and more recent complementarities before the focus turns to the theory of data network effects.

First, the six pharmaceutical firms had difficulties with differentiation in terms of their product market strategies. Here, these strategies refer to a firm's actions to achieve and maintain a competitive advantage through positioning in product markets (Porter, 1985). The efficacy profiles of the available replacement factors were similar. This similarity led firms, one by one, to attempt to differentiate themselves by introducing digital services in the form of a patient-centric app that provided various disease management functionalities. This measure focused on the realization of positive complementarities between a firm's offerings. The idea is that the value of A is greater in the presence of B than other alternatives such as A by itself or A and C together (Brandenburger and Nalebuff, 1996, Ennen and Richter, 2010). This attempt at differentiation through complementarities was unsuccessful because the pioneering firms' introduction of digital services was quickly imitated by followers, which restored the status quo of a lack of differentiation. By introducing the digital disease management systems, the six pharmaceutical firms obtained data network effects to a minor extent only because of their small user base given that their users were restricted to patients who used their products. Small businesses find it difficult to develop scale-up and scale-up advantages and, as a result, face barriers to innovation capabilities (Hilmersson, & Hilmersson, 2021).

Alfa's intention was to exploit a latent unaddressed market opportunity by activating stronger data network effects from reaching as many hemophiliacs as possible and not being limited to users of a specific brand of replacement factor, thereby acquiring larger data sets than any competing service. This approach provided patients with high-quality recommendations, thereby achieving lock-in of users of their services. However, the initial attempt failed for two known reasons. First, there were limitations in the user-centric design of Alfa's services. Second, Alfa

was unable to provide accurate enough recommendations for replacement factor usage. This second reason for failure was due to the lack of data volume because of slow user adoption of the disease management service. In this case, Alfa did not succeed in activating strong data network effects (Gregory et al., 2021). This failure is predicted by the theory of data network effects, which holds that users' perceived value of a service is conditioned by the accuracy of the predictions used to make recommendations. This relationship is, in turn, co-conditioned by the required volume of data and by the user-centric design of such services.

To overcome this failure, Alfa targeted another potential user of the same data, namely the regional authorities and, subsequently, the national Dental and Pharmaceutical Products Beneficiary Agency. They were offered value from alternative analysis of the same data. By identifying overdosage and underdosage of the replacement factor, Alfa pinpointed sources of substantial unnecessary costs in terms of both wasted medication and extra healthcare provisions due to undermedication. The value for the regional authorities lay in being precisely informed about where their subsequent measures should be focused to reduce overmedication and undermedication. The value for the Dental and Pharmaceutical Products Beneficiary Agency came from their understanding of the actual usage of these products as a foundation for forthcoming price renegotiations with pharmaceutical firms. The key to this retargeting of stakeholders lay in the authority of these new users of the data analysis to grant access to all the available user data generated by hemophiliacs from their use of the various disease management systems. They had the authority to legitimize data access, and they did so because it gave them valuable insights. Once this access had been secured, Alfa enhanced the user-centricity of its services, improved the quality of replacement factor usage recommendations based on the larger set of data, and relaunched the disease management app to the patients more successfully.

This detailed exploration of Alfa's successful path of entry to the marketplace shows that a key enabler for that success was the provision of services to a broader range of stakeholders than those previously reached with existing services. To confirm the validity of this success factor, a follow-up confirmatory study was conducted. Representatives of the targeted stakeholders were asked about their perceptions of these services. The follow-up study is detailed in the Appendix A. The results confirm that all stakeholder groups are highly satisfied with Alfa's services.

This case shows that users of machine-learning-based services should be regarded as multiple current and potential actors. These users have varying needs. Crucially, multiple actors can receive various machine learning services derived from the same data sets. This study also shows the importance of temporal unfolding, where current and potential users co-evolve together with the services being provided. There are various interdependencies between actors, data sets, and services. In the context of market entry by SMEs, this study's results suggest that SMEs can successfully enter a market dominated by pioneering incumbents by securing legitimate access to existing user data needed to derive services through machine learning.

6. Marketing Plan

The research question addressed in this study is as follows: What pathway can SMEs follow to enter a market with entry barriers that arise from incumbents' data network effects? The following insights emerge in response to this question.

This study offers at least five contributions to theory advancement. The first regards the notion of the user of machine-learning-based services. The theory of data network effects holds that a single human individual uses such services. While this situation may be the case, this study shows that the notion of a user should be broader. The empirical evidence is that users may include several social actors, both individuals and organizations, which use the same services or different services generated from the same data sets. This finding leads to the notion of the multi-actor user, as opposed to the single-actor user currently conceived by the theory. The present study shows that different actors that use the same or different services generated from the same data sets can have a range of profiles, with diverging interests and thus different legitimacy standards (Suchman, 1995). Hence, this expansion and diversification of the notion of the user implies that

the factor of data privacy use, which co-conditions perceived usefulness, must be updated as well. More specifically, it needs to be diversified to account for each user actor, where data privacy use requirements may vary with each actor. Similarly, the other co-conditioning factors of perceived usefulness (i.e., performance expectancy, effort expectancy, data quality and quantity, speed, and accuracy) may have different requirements for each user actor. These requirements may diverge, as this case shows. The divergent nature of the multi-actor user introduces varying interests and incentives. Alignments, misalignments, and conflicts of interests may all arise. This scenario complicates the present version of the theory of data network effects, which currently only considers single users their own individual cognitive apparatus.

The second contribution comes from the observation that stakeholder theory (Freeman, 1984) can shape the understanding of the dynamics of data networks. Multiple stakeholders condition the activation of such networks. A firm's stakeholders are understood as "any group or individual who can affect or is affected by the achievement of the organization's objectives" (Freeman, 1984: 46). Examples of stakeholders include customers, their customers, suppliers, employees, owners, investors, NGOs, and regulators. Stakeholder theory predicts that a firm's positive relations with stakeholders contribute to firm performance, as opposed to a situation with negative stakeholder relations (Berrone et al., 2007, Godfrey, 2005, Hillman and Keim, 2001). Whereas the mainstream strategic management literature focuses on the competition (Barney, 1991, Porter, 1985), the stakeholder approach emphasizes the very existence of a firm's stakeholders and the need to cooperate with them, or, in the words of Freeman (1984: 65), "stakeholder interests are joint." Accordingly, value co-creation with stakeholders is at the heart of stakeholder theory (Freeman, Harrison, & Wicks, 2007). To establish positive relations with stakeholders, the firm should take actions to make stakeholders perceive that it treats them fairly and rewards them (Hosmer & Kiewitz, 2005). The present empirical case study validates these predictions. As beneficiary agencies legitimize the access and use of patient data, these agencies are themselves rewarded, as is Alfa. However, some studies suggest that deliberate stakeholder management does not apply to SME success (Perrini, 2006). These studies are contradicted by the current findings, which imply that an SME can benefit from deliberate stakeholder management. This study shows that the activation of data network effects may be conditioned by actors other than the direct users of a machine-learning-enabled digital service. Moreover, these other actors may play a crucial role in the success of the service and the firm that provides it. Therefore, the findings of this study suggest that the implications of stakeholder theory can lead to further developments in the theory of data network effects (Clough and Wu, 2022, Gregory et al., 2021). This conclusion may be especially relevant for understanding how the use of machine learning technology can enable (a) value co-creation (Freeman, Dmytriyev, & Phillips, 2021), (b) business innovation, given that stakeholder management tends to correlate with firms' strong learning (Harting et al., 2006, Heugens et al., 2002, Roome and Wijen, 2005), and (c) an organization's establishment of social legitimacy (Heugens, van den Bosch, & van Riel, 2002), which is crucial for the activation of data network effects (Gregory et al., 2021).

The third contribution of this study also relates to the theory of data network effects. The current theory suggests an atemporal notion of data network effects, with regard to who the user is and what user needs must be fulfilled. However, the present study shows a different situation. There may in fact be multiple current and potential users of services derived from the same data sets. Because there may be several competing providers of machine-learning-based services, variations may emerge with regard to which user actors are provided with what services, by which providers, and when. As this case shows, several providers (pharmaceutical firms) initially targeted a certain user actor (patients). Next, the start-up attempted to target the same user actor in an approach that failed. The start-up subsequently targeted another user actor (authorities). This co-evolution illustrates the use of the same data sets, for similar or varying services, by a range of providers, with the start-up gaining access to a large volume of data and generating superior services. Altogether, the notion of the multi-actor user and the temporal understanding of services and users lead to an

updated notion of the theory of data network effects to account for these two related features.

The fourth contribution pertains to the literature on market entry by SMEs. The current literature on bypassing entry barriers is built on the industrial organization literature, with three main approaches: higher differentiation, broader scope, or niche markets (Acs, 2006; Arendt, 2008, Demsetz, 1982, Pehrsson, 2009). While these market entry strategies work for certain situations, they were conceived before the use of machine learning technology in service provision. Therefore, they are prior to the emergence of data network effects. However, they are invalidated by the data network effects that lock in the user-base and lock out competitors, which lack the relevant user data to generate high-quality services. The present study shows that an SME can successfully bypass the entry barriers erected by incumbents' activation of data network effects. An SME can enter a market by accessing the user data employed by incumbents. This access can be achieved by targeting another stakeholder's latent needs by offering machine learning-based services that require the same data as that used by incumbents. This stakeholder must have the authority and willingness to grant and legitimize this data access (Dwivedi et al., 2015, Zimmerman and Zeitz, 2002). This willingness can be incentivized by the SME's offering. Once this stakeholder's needs have been met by the new services that activate data network effects, the SME can focus on other stakeholders targeted by incumbents with services based on the same data. This study thus reveals a pathway for SMEs to enter a market with entry barriers based on incumbents' activation of data network effects.

The fifth contribution is a result of the interpretation of the case explored in this study. With multiple actors in the form of firms, authorities, professionals, and individuals, data network effects account for, explain, and predict the course of actions that unfolded. This finding is important because data network theory is a recent theoretical contribution with limited empirical support (Clough and Wu, 2022, Gregory et al., 2021). Examples include the prediction that low user centricity and low data volume will hinder service providers' ability to generate high perceived user value from machine-learning-based services. The investigated start-up failed with these features of user centricity and data volume, which contributed to its initial lack of success. Once the start-up managed to resolve these issues, it relaunched its services successfully. This study thus offers a unique independent validation of the proposed theory of data network effects.

6.1 Implications for practice

The results offer several insights for practitioners. First, managers of both SMEs and incumbents that intend to invest in machine-learning-based services should first consider whether they wish such investment to be strategic. To play a strategic role for firms, machine-learning-based services must have the potential to achieve data network effects in such a manner that users become demotivated to migrate to alternative providers, while competitors struggle to establish high-quality services because of a lack of data access. If these conditions cannot be met, then the planned initiative will probably lack the potential to play a strategic role.

Second, the question of who will use the potential services or who may become a user of existing services or a given dataset is important. In non-trivial situations, several actors may become users of services. Some will generate usage data to help with the provision of services, while others will not. In such multi-actor user situations, it is crucial to decide which users will be provided with services and in which order. There are two key kinds of stakeholders. Those who generate usage data for machine learning to produce the service and those who legitimize access to such usage data. For strategic investments in machine learning use, managers may therefore benefit from adopting a temporal perspective to conceive which actors should be targeted by which services, who will generate the crucial data, and how such data can be legitimately accessed. This planning may involve competitors that also seek to provide similar services to the same users, the potential choice of users, and data access. Such planning can help make the right decision at the right time.

Third, firms that do not pioneer a given machine-learning-based service may struggle to enter a market because the pioneer has access to a large, unique set of user data that can help produce a superior service. While larger firms may compete

head-to-head and use complementary services to attract a user base, SMEs typically lack such resources and struggle to enter the market, even when they have superior analysis technology. The pathway to bypass such barriers is to identify one or more stakeholders that can grant legitimate access to user data. For example, they can establish whether actors with the powers to provide access to data may benefit from services that are generated from the same data set that is targeted by the SME. There may then be an incentive for these actors to grant access to such data.

Fourth, policymakers should reflect on the possibility of establishing anti-trust policies that grant open and secure access to all user data equally for all actors. Such a policy could eliminate entry barriers based on access to user data, thereby leading to increased innovation and competition, which is a key source of user value creation over time.

5.3. Limitations and future research

The results of this study are original and contribute to knowledge on this topic. However, the results are derived from the exploration of a single case. Moreover, this case is rooted in the pharmaceutical industry, which has specific characteristics and heavy regulations. Also, the study represents a situation in a Northern European country, which has stable, advanced institutions. These factors may condition the results, so this study should be replicated in both similar and different contexts. Alternative contexts should cover other industries and other countries with specific characteristics to compare the results with those presented here. Another limitation is that the study offers only one possible pathway for an SME to enter a market with entry barriers based on incumbents' data network effects. Future research should investigate whether there are other pathways that also enable market entry. Finally, the activation of data network effects seems to be co-conditioned by stakeholders. Future research should combine the relevant components of stakeholder theory with the theory of data network effects to characterize how stakeholders condition the success or failure of data network effect activation.

7. Finance and Fundraising

In establishing a finance and fundraising plan based, the startup should carefully consider its cost structure and revenue streams. The study emphasizes that the notion of a user in machine-learning-based services is broader, encompassing various social actors, both individuals and organizations. This expanded understanding introduces the concept of a multi-actor user, suggesting the need for a diversified approach to address diverging interests and legitimacy standards. To address this, the startup must allocate funds for different user actors, taking into account their varying requirements in terms of data privacy, performance expectancy, effort expectancy, and other co-conditioning factors.

Regarding revenue streams, the study highlights the role of stakeholder theory in shaping data networks. Positive relations with multiple stakeholders, including customers, suppliers, employees, and regulators, are crucial for firm performance. Therefore, the startup should consider incorporating stakeholder management strategies into its financial plan to establish positive relations and facilitate the activation of data network effects.

The study's third contribution challenges the atemporal notion of data network effects, emphasizing the existence of multiple current and potential users of services derived from the same data sets. This suggests that the startup should anticipate variations in user actors and service offerings by different providers. Adaptability and flexibility in the business model will be crucial to navigate these dynamics successfully.

In terms of sales goals, a startup should set realistic targets for the near future and long term, considering the co-evolution of user actors and the temporal nature of services and users. Clear Key Performance Indicators (KPIs) aligned with the updated theory of data network effects should be defined to measure success and guide sales efforts.

Addressing the funding aspect, the startup should specify the amount of funding required from investors. Given the complexity introduced by the multi-actor user concept and stakeholder theory, the funding needs to encompass diverse requirements, including technology and infrastructure, human

resources, research and development, and stakeholder management initiatives.

8. Conclusion

The recent adoption of machine learning technologies enables organizations to activate data network effects. These novel uses of digital technology raise a new kind of barrier to followers who wish to provide similar services. Such barriers are particularly troublesome to SMEs, which typically lack the resources to compete head-to-head with large incumbents. The question addressed by this research is therefore as follows: What pathway can SMEs follow to enter a market with entry barriers that arise from incumbents' data network effects? The results suggest that a viable pathway to market entry for an SME, in such situations, is to incentivize stakeholders of such services to grant access for the start-up to use the necessary user data. Hence, it is the ability to establish legitimacy of data access, not ownership, that is the key to successful market entry when providing machine-learning-based services. This finding adds to the literature on how SMEs can bypass entry barriers. By extension, this study also adds to the theory of data network effects in two ways, namely by upgrading the notion of a service user from a single individual to a multi-actor user and by explaining data network effects temporally, where actors' decisions and actions co-evolve to create and capture value.

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Exploring the Interplay Between Tourist Co-Creation and Tourism Marketing Outcomes: A Relationship Characterized by an Inverted U-Shape

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1. Abstract

Extant literature typically advocates a positive linear relationship between a myriad of tourist co-creation behaviors and tourism business performance. This study challenges this conventional wisdom by probing the potential curvilinear effects of tourist co-creation on tourism marketing outcomes. The findings across three experiments manifest an inverted U-shaped relationship between the degree of tourist co-creation and an array of tourism marketing performance indicators comprising liking, participation, and recommendation intention. Furthermore, the results reveal that tourist experiential fluency may positively moderate this relationship, thereby offering measures to mitigate the negative impacts of excessive tourist co-creation on the ultimate tourism marketing outputs. This research makes theoretical contributions by cautioning against the possibility of value co-destruction and puts forward practical suggestions for tourism marketers to better manage the tourist co-creation process.

2. Introduction

Tourist co-creation generally refers to the active participation of tourists in the creation or modification of products or services related to their travel experiences (Campos et al., 2018). This participatory process can transpire in various phases of the tourism journey, including the pre-trip, on-trip, and post-trip stages, and may manifest through a multitude of channels including online platforms and direct interpersonal interactions (Tseng & Chiang, 2016). Previous studies have extensively identified a broad spectrum of benefits associated with fostering tourist co-creation (Mathis et al., 2016, Prebensen and Xie, 2017). Consequently, tourism practitioners are increasingly shifting their resources to incorporating tourists in the decision-making and experience formation process (Prebensen et al., 2013).

Despite the well-documented positive effects of tourist co-creation in the extant literature, it is not well understood whether such effects have limits. Admittedly, facilitating tourist co-creation can bolster tourist engagement and preference fit, thereby enhancing their overall touristic experiences and associated tourism marketing performance (Jaakkola et al., 2015, Sugathan and Ranjan, 2019). Nevertheless, on the flip side, tourist co-creation is simultaneously a highly complex and dynamic resource exchange process (Grönroos & Voima, 2013). Thereby, an excessive augmentation of tourist co-creation may also imply heightened costs and risks (Stokburger-Sauer et al., 2016). As such, given the presence of these two parallel but countervailing underlying mechanisms, it remains questionable whether there is a saturation point for the benefits that tourist co-creation can yield.

These reflections lead to the main investigation in the current study about whether there is an optimum of tourist co-creation in relation to tourism marketing outcomes. To the best of our knowledge, existing literature has primarily assumed a positive linear relationship between various tourist co-creation actions and marketing outputs (see systematic reviews by Campos et al., 2018, Phi and Dredge, 2019. Against this backdrop, this study resorts to the value co-destruction literature and conducts a critical review of the inherent benefits and costs embedded in the course of tourist co-creation, the results of which have directed us to theorize a negative curvilinear (i.e., inverted U-shaped) relationship between tourist co-creation and tourism marketing performance.

Further, to develop strategies for optimizing co-creation consequences, the current study also examines the conditions under which tourism marketing performance can continue to grow despite a high degree of tourist co-creation. Considering tourist co-creation entails intensive cognitive activities that require tourists to think, learn, and perceive (Gligor & Maloni, 2022), the present study refers to the cognitive psychology literature and draws upon the seminal processing fluency theory (Schwarz, 2004) to propose tourist experiential fluency, namely the cognitive smoothness, during the co-creation process as a moderating variable in this relationship. Specifically, it is contended that by elevating customer skills and knowledge and adjusting user interface design to promote tourist experiential fluency, improved tourism marketing outcomes can be attained.

We test the above propositions across three experiments. The results consistently reveal an inverted U-shaped pattern between the degree of tourist co-creation and a range of tourism marketing performance indicators encompassing liking, participation, and word-of-mouth intention, manifesting that although augmenting tourist co-creation can raise tourism marketing performance to a certain point, an overwhelming level would cause performance deterioration. In addition to that, the tests for the moderation effect indicate that fluent tourist co-creation experience can effectively counteract the negative impacts of excessive tourist co-creation on tourism marketing outcomes, offering hints for averting the risks pertinent to tourist co-creation activities.

Our research makes three main contributions. First, we provide one of the first pieces of experimental evidence for the negative curvilinear effect of co-creation on marketing outcomes in the tourism business context. The finding thereby challenges the commonly held presumption of a positive linear relationship between these two genres of constructs. Since tourist co-creation behaviors can be either value-creating or value-destructing, we call for subsequent theoretical construction to argue why in a given tourism business scenario the value co-destruction scenario is unlikely to occur. Second, we identify tourist experiential fluency as a boundary condition to determine the consequences of co-creation, which articulates the dynamics of the co-creation by bridging cognitive psychology literature. The finding sheds light on ensuing tourism co-creation research by highlighting the importance of concentrating on the customer's concrete cognitive experiences during the co-creation process to optimize co-creation outcomes. Third, for tourism practitioners, the current research warrants their attention to the hidden side-effects of excessive tourist co-creation. We highlight that co-creation can be a double-edged sword and that blindly increasing the level of tourist participation in the value-creation process does not necessarily guarantee enhanced business outputs. In this way, we emphasize the need for tourism practitioners to make informed decisions to affirm the optimal rather than the highest possibility of tourist co-creation.

The following sections are structured as follows: We first present the theoretical framework and research propositions in the next section, followed by a delineation of the methods and results of our three experiments. After that, we discuss our findings with existing literature to provide theoretical and practical implications. Finally, we present the limitations of the study as well as recommendations for future research.

3. Marketing Analysis

Viewing tourists as value co-creators represents a paradigm shift in understanding the process through which value is generated for both tourists and tourism businesses (Sugathan & Ranjan, 2019). Contrary to the conventional service marketing logic, which positions tourists as mere recipients of value, the co-creation approach acknowledges tourists as dynamic agents capable of contributing their own operand and operant resources to create value for themselves (Prebensen et al., 2013). As such, tourists should not be solely treated as passive visitors or sightseers, but rather as active participants in the construction of their own travel experiences (Alves et al., 2016).

Adopting this value co-creation perspective, extant studies have extensively gauged the positive effects of tourist co-creation in a myriad of onsite and digital tourism settings, unveiling abundant benefits for both tourists and tourism businesses. On the side of tourists, for instance, engaging in co-creation

activities can directly enhance their autonomy, preference fit, and sense of engagement (Grissemann and Stokburger-Sauer, 2012, Mathis et al., 2016), which in turn contributes to an elevated overall value perception of the journey, encompassing value attributes such as quality, financial, novelty, emotional, relational, and epistemic value (Guan et al., 2018, Prebensen and Xie, 2017, Xie et al., 2020). Consequently, such an increase in tourist perceived value would amplify tourist satisfaction as well as their well-being at large (Saha et al., 2022).

Likewise, on the side of tourism businesses, previous studies have found that enabling tourist co-creation is conducive to unlocking innovative ideas, removing barriers between stakeholders as well as strengthening brand uniqueness and equity (Assiouras et al., 2019, Carvalho and Alves, 2023). As a consequence of such benefits, a series of key tourism business and marketing outcomes, including service innovation success rate, service quality, tourist loyalty, word-of-mouth behavior, tourist expenditure, and business market share are all likely to be boosted (Grissemann and Stokburger-Sauer, 2012, Hollebeek and Rather, 2019, Sarmah and Rahman, 2018). Consequently, due to the multitude of benefits derived from tourist co-creation, incorporating tourists into the value-creation process has emerged as a crucial strategic approach and core business orientation for tourism service providers and destination management organizations to achieve competitive advantages (Saha et al., 2022).

Notwithstanding the well-researched benefits of tourist co-creation, scant literature has discussed its potential downsides. That said, it is largely taken for granted that tourism co-creation would linearly and unconditionally benefit the tourist experience and tourism marketing outcomes. This presumption, however, has been recently challenged by marketing researchers who argue that customer co-creation or active participation also entails certain risks and costs (Echeverri & Skålén, 2021). Therefore, it warrants further research attention to exploring the circumstances under which tourist co-creation can be value-destructing, which will be critically reviewed in the subsequent section.

As opposed to value co-creation, value co-destruction denotes the circumstances in which the interactions between actors in the value system result in the diminishment of value and well-being for relevant stakeholders (Zhang et al., 2018). Recent research has provided empirical evidence and theoretical articulations on the occurrence of value co-destruction in service and tourism marketing contexts (see reviews by Echeverri and Skålén (2021) and Freire and Veríssimo (2021).

The primary research stream on value co-destruction is developed from the resource-based viewpoint. As noted by Grönroos and Voima (2013), co-creation is essentially a resource-exchange practice inevitably demanding customers to invest and exchange their financial, physical, and intellectual resources such as ideas, skills, knowledge, expertise, and time. This implies that as the degree of co-creation increases, the required operand and operant resources from customers would also significantly rocket up (Gallarza et al., 2019). In the context of tourism experiential consumption, studies have demonstrated that when the degree of tourist co-creation is intensive, tourists who are relatively new to the destination or touristic activities may not always possess compatible resources to engage in meaningful participation (Freire & Veríssimo, 2021). As a result, issues of resource mismatching may arise, which in turn leads to negative consequences for both tourists and business outcomes (Freire and Veríssimo, 2021, Smith, 2013).

Apart from the issue of resource misalignment, prior studies have also investigated value co-destruction from psychological perspectives. As suggested by Wang et al. (2019), while customers usually view co-creation as a voluntary choice, it should be noted that all their inputs of operand and operant resources are not monetarily compensated. That said, when tourists perceive injustice and unfairness in the way they are treated during the co-creation process, they may transform their identities from “co-creators” to “unpaid employees”, combined with feelings of boredom, anxiety, frustration, and even “labor exploitation” (Cova et al., 2011, Freire and Veríssimo, 2021). This depriving sentiment can be particularly pronounced when the degree of required co-creation becomes overwhelming, and tourists

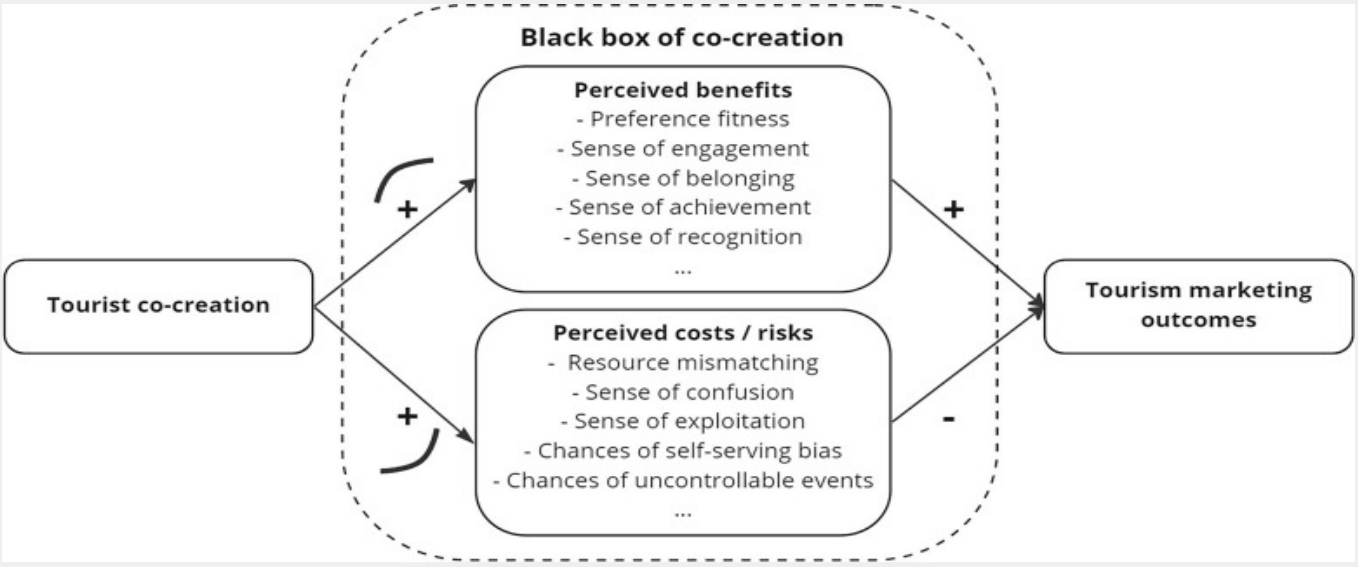

Fig. 1. The black box of tourist co-creation.

have to expend considerable time and effort to fulfill their "duties" (Guan et al., 2020).

Meanwhile, extant consumer psychology research has also suggested that value co-destruction may be associated with cognitive biases. For instance, implicated by the equity theory (Huppertz et al., 1978), as the volume of customer contribution soars, so does their expectation for outcomes, which can make it harder for the co-created experience to reach a satisfactory level given the same level of service quality (Childers et al., 2001). Similarly, the self-serving bias phenomenon (Bendapudi & Leone, 2003) posits that customers are more likely to attribute positive co-creation results to their own actions and negative co-creation outcomes to service providers' practices. Thereby, applying these findings to the tourism consumption context, doubts can be raised about whether tourists will equally attribute their experienced values to the service providers when the co-creation level is overly high.

Last but not least, several studies illustrate value co-destruction phenomena from the lens of complexity science. According to complexity theory, an increase in the number of actors and actions in a system naturally entails greater uncertainty, potentially leading to a higher probability of uncontrollable events, conflicts, and misbehaviors (Hallikas et al., 2004). As a result, the increasing co-creation activities would make it harder for service providers to monitor and control the service provision, which would eventually increase the possibility of service failure and negatively impact the customer experience (Wang et al., 2019). For instance, as found by Sthapit and Björk (2019), the friction in excessive customer interaction is shown to be a significant reason leading to tourist dissatisfaction.

In summary, the above review leads us to present Fig. 1, which illustrates the inherent costs and benefits associated with the tourist co-creation process, referred to as the "black box of co-creation". As can be revealed by Fig. 1, while extant research predominantly focuses on the positive sides of co-creation, there are, in fact, two parallel but countervailing underlying mechanisms transpiring the tourist co-creation process. That said, on one hand, tourist co-creation can elevate tourist perceived benefits, which in turn improves tourism marketing performance. On the other hand, tourist co-creation can also produce hidden costs and risks, which would in turn undermine customer evaluation and thus tourism marketing performance.

4. Competitive Analysis

Then, following the guidelines of theorizing curvilinear effects (Haans et al., 2016), we can couple with the law of diminishing marginal utility from microeconomics to argue that while tourists can obtain increasing benefits due to their co-creation actions, such benefits are likely to increase at a decreasing rate, resulting in a concave benefit curve. In the meantime, as the level of tourist co-creation increases, the costs linked to co-creation activities will exponentially increase, resulting in a convex cost curve. Consequently, the

additive benefits of tourist co-creation to the tourism marketing performance would point to a negative curvilinear pattern. That is, the tourism marketing outcomes led by the tourist co-creation will be enhanced at a declining speed until reaching the maximum, after which they will decline at a growing speed as the level of tourist co-creation behaviors continues to increase. As such, we can make our first proposition as follows:

Proposition 1
Tourist co-creation has a negative curvilinear (inverted U-shaped) effect on tourism marketing outcomes.

Given this first proposition, it is now both theoretically and practically important to further investigate under what circumstances the anticipated downturn occurring in high tourist co-creation conditions can be avoided. Previous co-creation literature has discussed that customer capability (i.e., skills, knowledge, expertise) may play a decisive role in affecting the relationship between customer co-creation and co-creation outcomes (Gligor and Maloni, 2022, Stokburger-Sauer et al., 2016). This is because, capable customers can better cope with and adapt to the challenges emerging in the co-creation process, which enables them to maintain a smooth and comfortable co-creation experience even though the degree of co-creation is immensely high (Yim et al., 2012). This discussion leads us to the idea that as long as tourists can undergo a fairly smooth co-creation experience, they will be less likely to detect and be negatively impacted by those underlying costs and risks pertinent to co-creation.

In the cognitive psychology research field, such an experiential feeling of smoothness is conceptualized as processing fluency, which is defined as the ease with which the information is processed (Lee & Labroo, 2004). One of the key determinants of processing fluency, as already noted, is related to customer capability as it can directly uplift people's cognitive power and self-efficacy during information processing (Hamann, 1990). Aside from that, processing fluency also pertains to the ease with which a person identifies the physical features such as clarity, modality, font, and size, contained in a stimulus, which is called perceptual fluency, as well as the ease with which a person understands the semantic meanings contained in a stimulus, which is called conceptual fluency (Tulving and Schacter, 1990, Winkielman et al., 2003).

Despite distinct sources of processing fluency, extant consumer psychology research shows that all fluent experiences would impose identically positive impacts on customer affective responses (Reber et al., 1998, Winkielman and Cacioppo, 2001). This is because, according to the seminal affect-as-information theory, fluent conditions (vs. disfluent conditions) would signal little harmlessness and higher familiarity, cognitive ease, and opportunities for success (Song & Schwarz, 2008). In the same vein, according to the flow theory, when people experience fluent thoughts and actions, feelings of enjoyment would naturally emerge (Drengner et al., 2008). As a result of these positive affect, customer judgment and behavioral intention toward the processed targets can be lifted though people may not always be aware of it. Some interesting instances include that stocks with simple names perform better than those with complex names, brands with easy-to-understand features yield higher customer trust than those with difficulty-to-understand features, and suggestions printed with clear fonts are more likely to be accepted than those with intricate fonts (Schwarz et al., 2021).

In the tourism marketing context, existing literature has also provided supportive evidence for such a fluency-pleasure relationship (Orth & Wirtz, 2014), as well as the positive moderating effect of processing fluency on ultimate marketing outcomes. For instance, Tang and Jang (2014) found that processing fluency can positively moderate the relationship between utilitarian value elicited by web material and destination image. This implies that when information related to a destination is easily understood and processed, it can lead to a more positive perception of the destination. Similarly, in the context of CSR communication, Zhang et al. (2018) found that when the material is easy to process, tourists tend to have a more positive attitude toward the CSR campaign. This suggests that facilitating the processing fluency of CSR information can enhance its effectiveness and contribute to a more favorable evaluation of the campaign.

Following the above-elaborated psychological mechanisms and empirical cases, we can argue that in the tourism co-creation context, tourist experiential fluency could be one of the essential moderators in determining the relationship between tourist co-creation and tourism marketing outcomes. That is, when the co-creation experience is fluent, tourists' mindsets are expected to be positively triggered, making their interests, motivations, and attitudes to respond to an increase in the co-creation intensity more favorable; as such, an increase in the degree of tourist co-creation will lead to a smaller increase in the perceived costs and a larger increase in the perceived gains. According to Haans et al. (2016), such a transformation would shift the turning point of our proposed inverted U-shaped curve to the upper right, which can be postulated as a positive moderating effect. Based on these arguments, we can put forward the second proposition below. Then, in the following sections, we present the methods and results of three experiments conducted for proposition testing.

Proposition 2

Tourist experiential fluency positively moderates the negative curvilinear (inverted U-shaped) relationship between tourist co-creation and tourism marketing outcomes.

5. Product Design

In experiment 1, we set out to test the first proposition by operationalizing tourist co-creation in an online package-tour co-creation setting. We used a real-life package tour product called "Nutshell in Norway", which allowed us to systematically vary the required degree of tourist co-creation such as time investment, information provision, and preference expression while controlling for extraneous variables. Specifically, we conducted a single-factorial between-subjects online experiment using an Amazon Mechanical Turk (MTurk) sample who participated in return for a small monetary reward. The manipulation technique was to ask participants to perform a simulated package tour reservation task based on "Nutshell in Norway". To effectively manipulate the degree of co-creation (low vs. moderate vs. high), we intentionally varied the number of service options needed for reviewing, reflecting, and selecting, ranging from transportation, accommodation, catering, and specific touristic activities.

A pre-test with college students in Norway affirmed a significant difference in terms of the perceived degree of co-creation (items: "I have been actively involved in the packaging of my trip" "I have used my experience from previous trips in order to arrange this trip" "The ideas of how to arrange this trip were predominantly suggested by myself", scales 1——7, from Grissemann and Stokburger-Sauer (2012) between the three levels ($\alpha = 0.85$, During the actual online experiments, the MTurk participants were randomly assigned to one of the three experimental conditions and were instructed that they were going to co-create a package tour in Norway and then make evaluations. After completing the task, the participants were required to report their attitudinal evaluation, namely liking, toward their co-created package-tour product (item: "how much you like this Norwegian package-tour offering", scale 1——7). As a manipulation check, we asked them to rate their perceived co-creation degree as we did in the pretest. Regarding covariates, we measured their attitude to Norway and their familiarity with Norway as a destination (scales 1——7). In the end, the participants reported their demographic information.

5.1 Results and discussion

The manipulation check revealed a significantly different perceived degree of co-creation between the three conditions, After that, Analysis of Covariance (ANCOVA) with attitude and familiarity as covariates, manifested a significant main effect of co-creation on liking, and the post hoc comparisons further revealed significant differences between the low and moderate conditions, between the moderate and high conditions, and between the high and low condition conditions. Fig. 2 demonstrates the estimated marginal means of liking in three co-creation conditions.

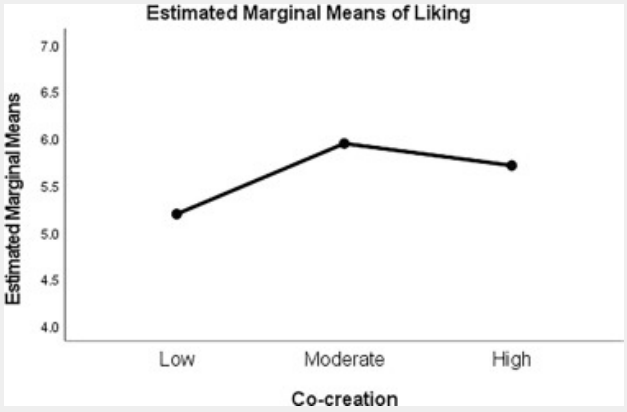

Fig. 2. The relationship between tourist co-creation and liking.

The results of experiment 1 indicate that participants' co-creation level had a significant main effect on their liking toward their co-created package tours and that the net relationship between the degree of tourist co-creation and liking did follow a negative curvilinear (inverted U-shaped) pattern as presented in Fig. 2. Therefore, our first proposition was preliminarily supported in this experiment. Despite the expected results, a limitation of this study is that those MTurk participants were not actual tourists who are intrinsically motivated to spend time and effort on this co-creation task. Additionally, the online experiment may not have effectively controlled for environmental covariates. To address these limitations, the next experiment will replicate experiment 1 using an event manipulation technique to vary the co-creation level and continue to test our second proposition.

In experiment 2, we conducted a single factorial between-subjects experiment with a student sample who were freshmen from three classes studying at a university in eastern China. Similar to study 1, we designed a field trip co-creation task intended to vary their perceived degree of co-creation (low vs. moderate vs. high). In this experiment, we designed a tour based on a local destination in which the university is located. The rationale for this design was that 42.4% of the students were local residents who just graduated from high schools in the same city as the university is located. Therefore, we expected that this characteristic of the sample could enable a natural variation in experiential fluency as such local students would have more relevant experiences and knowledge when processing the co-creation tasks. That said, the local students expected to undergo a higher experiential fluency while co-creating their stay than the others who just commenced their bachelor's studies in this relatively new city.

To simulate realistic tourist co-create experiences, we applied an event technique to manipulate the degree of co-creation. First, we randomly assigned one co-creation scenario to each class. Then, at the beginning of each round of the experiment, a marketing course lecturer, who reacted as the experimenter in this study, instructed students in the class that the faculty had planned a two-day field trip for them in the coming spring semester and would like to learn about their preferences concerning this field trip. Then, students were asked to use their computers and click a link that directed them to their assigned online package-tour co-creation scenario. During the task, they had to individually co-create their assigned trip scenario in the online form. After completing the task, the students continued to complete a questionnaire measuring their liking (item: "how much do you personally like this field trip plan", scale 1–7) and participation intention as a downstream consequence (item: "how likely you are participating in this field trip", scale 1–7). Then, the manipulation check was made as in study 1, followed by measuring their perceptual fluency during the task (item: "difficult-easy to process the co-creation task", scale 1–7, from Graf et al. (2018)), and their attitude to the field trip site as a covariate (scale 1–7). Finally, the students reported their demographic information items. A debriefing was made by the lecturer about the purpose of the study after the experiment.

5.2 Results and discussion

As predicted, the manipulation check showed significantly different perceptions of the co-creation level between the three conditions. fter that, we conducted a Multivariate Analysis of Covariance (MANCOVA) with the attitude toward the field trip site as a covariate to test whether there existed differences between the degree of co-creation and the two outcomes (liking and participation intention). The results manifested a statistically significant MANOVA effect. In terms of liking, the post hoc comparisons further revealed significant differences between the low and moderate conditions, and moderate and high conditions, and a non-significant difference between the high and low conditions. As for the participation intention, the

post hoc comparisons revealed that the low condition was significantly lower than both the moderate condition and high condition, yet no significant difference between the moderate and high conditions was found. Fig. 2 demonstrates the estimated marginal means of liking and participation intention in all three co-creation conditions.

To test the moderating effect of perceptual fluency, we conducted a multiple-moderated regression analysis. Following Hayes (2013), we treated the low co-creation as the baseline and respectively regressed liking and participation intention on the

attitude, effect-coded level of co-creation, and mean-centered experiential fluency, followed by entering the mean-centered interaction effects. As can be seen from the regression results depicted in Table 1, in both model 1 and model 2, the omnibus F-tests were not significant and accordingly the coefficients of interaction terms were not significant as well. Therefore, the results did not support a significant moderation effect.

The results of study 2, again, disclosed an inverted U-shaped relationship between the degree of tourist co-creation and liking, which supported our first proposition. As for the participation intention, even though it did not fully resemble an inverted U-shape, the results indicated that the high condition did not yield a better outcome than the moderate condition.

	Liking				**Participation Intention**			
	Model 1a		**Model 1b**		**Model 2a**		**Model 2b**	
Independent variables	b	t	b	t	b	t	b	t
Constant	4.844	14.082**	4.845	14.157***	5.305	15.305**	5.284	15.139**
Attitude	0.02	0.289	0.018	0.26	−0.049	−0.709	−0.043	−0.615
Low CC (baseline)	–	–	–	–	–	–	–	–
Moderate CC	0.608	3.53**	0.637	3.707**	0.41	2.362*	0.402	2.294*
High CC	0.304	1.752	0.325	1.885	0.489	2.796**	0.49	2.785**
Fluency	0.164	3.177**	0.245	2.467*	0.15	2.876**	0.078	0.771
Moderate CC*Fluency			−0.235	−1.73			0.072	0.521
High CC.*Fluency			−0.027	−0.216			0.114	0.896
R^2	0.157		0.182		0.113		0.119	
Adj.R^2	0.13		0.143		0.085		0.076	
F(df)	5.914 (4) **		4.647 (6) **		4.042 (4) **		2.803 (6) **	
$\triangle R^2$	0.067		0.025		0.058		0.006	
△F(df)			1.936 (2)				0.401 (2)	

Notes: * p<0.05; p<0.01; CC: Co-creation.

Table 1. Moderating Test Results

Hence, we found support for proposition 1 in this experiment. Regarding the moderating effect of experiential fluency, we however did not find supportive results for proposition 2. As a reflection, such nonsignificant results might be due to several unavoidable limitations in this study. For example, when we checked students' self-reported fluency value, the results showed that most participants perceived the co-creation tasks as somewhat easy to process, putting doubts on the efficacy of our intended natural variation technique. Hence, in the following experiment, we continued to replicate the study with a larger sample and intentionally manipulate the experiential fluency to further validate our propositions.

In experiment 3, we conducted a 3 (co-creation level: low vs. moderate vs. high) by 2 (experiential fluency: low vs. high) between-subjects experiment. The participants of this study were sophomores and juniors from six classes in the same university as in experiment 2. In this experiment, we adopted the stimulus we developed in experiment 1 with the language being translated into Chinese by a bilingual tourism marketing researcher from Norway. Different from study 2, we hereby intentionally manipulated the experiential fluency of the co-creation task. For the sake of contextual realism, we referred to Herrmann et al. (2013) to respectively vary the experiential fluency by modifying the font (Simsun vs. STXingkai), font size (12 vs. 10), and Michelson contrast (0.7 (RGB background: 0,0,0; RGB text: 255,255,255) vs. 0.45 (RGB background: 0,0,0; RGB text: 150,150,150)).

The experimental procedure was similar to study 2. We first randomly assigned one co-creation scenario to each class. Then, at the beginning of the test, the lecturer instructed students in the class that the faculty had planned a summer exchange program in Norway for future students and would like to learn about their opinions concerning the arrangement of a 2-day journey in this program. Then, students received the link and used their computers to conduct the co-creation process. When they finished the task, they were required to complete a questionnaire measuring their liking (item: "how much do you personally like this 2-day field trip", scale 1–7) and another downstream marketing outcome which is the word-of-mouth (WOM) intention (item: "how likely would you recommend this trip to your future peers who intend to join this Norwegian exchange program", scale 1–7). Likewise, the manipulation checks for participants' perceived co-creation degree and experiential fluency were made as in Experiment 2, followed by measuring their attitude toward Norway as a covariate and collecting their demographic information. A debriefing was conducted at the end by the lecturer.

5.3 Results and discussion

The manipulation check, as expected, showed a significantly different perception of the degree of co-creation between the three co-creation conditions as well as a significantly different experiential fluency between the two processing fluency conditions. After that, we performed a two-way MANCOVA, with the destination attitude as a covariate for our propositions testing. The results showed a significant main effect of co-creation as well as significant interaction effect of co-creation × fluency on the combined dependable variables.

Specifically, in the high fluency condition, the results of pairwise comparisons showed significant differences in liking between the low and moderate conditions between the low and high conditions, and no significant difference between the moderate and high conditions. As for the WOM intention, the results showed significant differences between the low and moderate conditions between the low and high conditions and no significant difference between the moderate and high conditions.

In the low fluency condition, the results showed significant differences in liking between the moderate and high conditions and no significant difference between the low and moderate conditions As for the WOM intention, the results showed significant differences between low and moderate conditions between the moderate and high conditions and no significant difference between the low and high conditions.

Concerning the moderating effect, the results of simple effect analysis showed that, in the conditions of high co-creation level, there were significant differences in both liking and WOM intention between the low and high fluency conditions. While

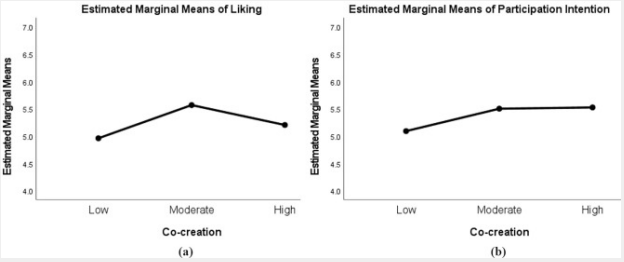

Fig. 3. The relationship between co-creation, liking, and participation intention.

in both the low and moderate levels of co-creation conditions, the interaction effects were not significant. Finally, the estimated marginal means of liking and WOM intention across three co-creation degrees are visualized in Fig. 3.

In consequence, it can be seen in Fig. 4 that the relationship between the degree of co-creation and liking and WOM intention basically followed an inverted U-shaped curve in both experiential fluency conditions, with the moderately co-created package tour being liked and recommended most. Thus, the results, again, supported our first proposition. As for the second proposition, the interaction effect was significant when the tourist co-creation degree was high, indicating that tourist co-creation was able to impart more positive influence on customer liking and recommendation intentions when there was higher tourist experiential fluency. As such, the results provided us with supportive evidence for our second proposition as well. In the following section, we further discuss the results obtained from three experiments with extant literature to present theoretical and practical implications.

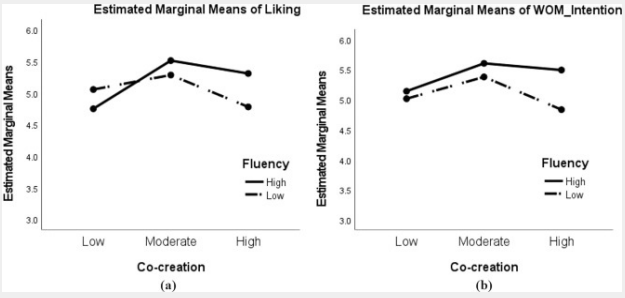

Fig. 4. The relationship between tourist co-creation, liking, and WOM intention.

6. Marketing Plan

In a nutshell, our study proposed and examined the potential inverted U-shaped relationship between tourist co-creation and tourism marketing outcomes. Results from three experiments consistently manifested that cementing tourist co-creation from a very limited level to a moderate level would significantly enhance tourist liking, participation, and recommendation intention toward the corresponding touristic activities. The findings thereby affirm previous research that extensively highlights the significance of treating tourists as value co-creators in promoting tourism marketing and business performance (Mathis et al., 2016, Prebensen and Xie, 2017, Saha et al., 2022). In this respect, we have addressed the call for adopting a tourist-centric paradigm when designing, planning, and innovating tourism offerings (Phi & Dredge, 2019).

A more symbolic finding distinct from extant literature is that, compared with a moderate level of co-creation, a high degree of co-creation would not necessarily improve and can even cause a downturn in tourist evaluative attitudes and behavioral intentions. This decline, as what has been reviewed, can be articulated from both the resource-based viewpoint and customer psychology perspective (Cabiddu et al., 2019, Homburg and Kuehnl, 2014). In our cases, along with the increasing co-creation degree, the research participants had to spend more time and effort on reading, searching, checking, communicating, and reflecting on how to choose from all the alternatives. Consequently, those participants in high co-creation conditions might end up in a situation where they feel bored, incapable, and unwilling to proceed with the co-creation tasks (Echeverri and Skålén, 2021, Zhang et al., 2018). Eventually, such time and attention costs, coupled with burdensome feelings and cognitive overload, may surpass the benefits brought by the co-creation and induce a downgrade in several marketing performance indicators.

This finding, being rather novel in tourism marketing studies, echoes other empirical value co-destruction research in general marketing and management contexts. For instance, Homburg and Kuehnl (2014) displayed a negative curvilinear relationship between the degree of customer integration and product innovation success. Recently, in the supply chain management context, Gligor and Maloni (2022) found an inverted U-shaped relationship between value co-creation and customer satisfaction. In this way, our study

extends the value co-destruction literature by presenting another solid piece of experimental and causal evidence in the scenario of package-tour co-creation, showing that tourists can also be value co-destroyers when the co-creation degree reaches an excessively overwhelming level.

The inverted U-shaped relationship is important because it suggests that there is an optimal level of tourist co-creation that leads to the best tourism business performance. If co-creation is too low, it may not provide enough value to the customer and the business may not realize its potential benefits. On the other hand, however, if co-creation is too high, it may become too complex or costly for tourists and businesses to manage, leading to decreased performance. Understanding this relationship helps businesses to determine the right balance between tourist co-creation and performance, maximizing the benefits and minimizing the costs of the co-creation process.

Beyond that, our study further investigated the dynamics in the "co-creation black box" by integrating tourist experiential fluency as a contingency factor in the relationship between tourist co-creation and tourism marketing outcomes. We have identified that the valence and consequence of tourist co-creation depended upon their cognitive fluency in the co-creation process. Specifically, the results showed that when the tourist involvement was intensive, an increase in tourist co-creation induced higher liking and recommendation intention in the fluent condition than in the disfluent condition. The results are in line with extant tourism marketing and consumer psychology literature documenting that the sense of fluency is essentially hedonically marked (Lee and Labroo, 2004, Schwarz et al., 2021) and can elicit positive affective responses and cognitive judgment (Tang & Jang, 2014).

More importantly, this finding expands our understanding of how to boost tourist co-creation outcomes. Extant literature mainly focuses on elevating customer capabilities such as skills and knowledge to enhance the co-creation experience (Gligor and Maloni, 2022, Stokburger-Sauer et al., 2016). Whilst customer capability is undoubtedly a theoretically valid customer variable, it could be formidable for tourism providers to always select tourists based on such preferable traits or conduct tourist education to enhance their co-creation capabilities prior to the journey (Wang et al., 2019). As such, by identifying processing fluency as a positive moderator in the current study, tourism researchers can explore the antecedents of tourist experiential fluency and focus on the concrete design of co-creation materials to probe more co-creation optimization strategies.

Taken together, now that business value can be both co-created and co-destructed depending on the exact co-creation degree and specific customer co-creation experience, it would be questionable to always normatively conceptualizes a positive linear relationship between co-creation and business outcomes. Nevertheless, as noted in existing reviews, tourism marketing literature has heavily focused on the positive sides of tourist co-creation behaviors, or value co-creation, and less has been centered on the dark sides of co-creation, or value co-destruction. In this case, our research suggests that co-creation should be deemed as an analytical and utilitarian construct with neutral semantics and cautions ensuing tourism researchers to keep the potential embedded costs and risks of the co-creation in mind and should not take it for granted that tourist active participation is always value-creating. That is, when theorizing a positive linear relationship between an array of tourist co-creation actions and business performance indicators, they should argue how the overwhelming scenario is not likely to occur in a certain tourism service or marketing context.

7. Finance and Fundraising

Our study proposes threefold implications for tourism practitioners. First, the results of our research do indicate enhanced marketing outcomes when the tourist involvement in the value formation process elevated from very little to a moderate extent. Therefore, we fully recognize the significance of a co-creation mindset for tourism practitioners. Especially in the nowadays highly competitive tourism market environment with homogeneous tourism offerings, we would support and encourage tourism marketers and managers to leverage possible offline and emerging digital tools to establish interactive touchpoints with tourists so as to provide them with individualized and highly engaged service experiences.

Nevertheless, as the saying goes “too much water drowned the miller”, tourism practitioners need to be simultaneously aware of the potential costs and risks carried by tourist co-creation activities. That said, whilst too little co-creation limits meeting customer needs and preferences, too much co-creation can also lead to the risks of resource misalignment and customer dissatisfaction, both of which can be detrimental to the ultimate business and marketing performance. As such, tourism service providers and marketers must find the right balance and determine the peak point of tourist co-creation in concrete service encounters. To achieve that, corresponding market research, pre-tests, and experiments are helpful to detect the optimum level of required tourist co-creation actions, especially when issuing service offerings containing demanding co-creation requirements to the market for the first time.

Following that, as suggested in our study, one efficacious strategy to manage the tourist co-creation process is to center on facilitating tourist experiential fluency during the co-creation process. To achieve that, it is always advisable to check whether tourists have adequate information and applicable knowledge to accomplish the co-creation tasks. If not, the tourism providers must intervene in the co-creation process to offer instruction and assistance. Noting that very often tourism practitioners cannot conduct customer education or select only those “expert tourists”, tourism marketers can shift to the concrete co-creation interface design to ascertain the smoothness of the co-creation procedure. In principle, the materials (e.g., texts, images, procedure, etc.) contained in the co-creation interface have to be streamlined with high readability, clarity, and coherence. This can be realized via breaking down complex information into simpler, more manageable pieces and modifying specific visual and auditory attributes such as font, size of the words, figure-ground contrast, and so forth. Especially in the online co-creation context, it is necessary to warrant that artistic and sophisticated interaction design should not sacrifice the ease of processing.

This research has several limitations that could be addressed in future studies. First, our conceptual framework considers tourist experiential fluency as a contingency factor. Future research could investigate other potential moderators (i.e., for whom and under which conditions) that may influence the relationship between co-creation and business performance. Second, in all three experiments, we only operationalize tourist co-creation in pre-trip package-tour settings. Future studies should explore broader digital and on-site contexts during and after the trip, as co-creation encompasses various activities throughout these stages (see Yi and Gong (2013). Additionally, in studies 2 and 3, we tested our propositions using student samples, which may limit the generalizability of the research findings. As such, caution is needed when extrapolating these findings to other contexts. To address this issue, we strongly encourage future studies to improve ecological validity by conducting field experiments to establish the causal relationship between specific co-creation actions and business outcomes in realistic marketing scenarios.

Firstly, a significant portion of the budget should be allocated to ongoing research and development. This investment aims to further explore and understand the implications of tourist co-creation. It may involve hiring research professionals, conducting market studies, and investing in technology to track and analyze consumer behavior.

Another crucial aspect is technology investment. Allocating resources for the development and integration of digital tools is essential to facilitate interactive touchpoints with tourists. This includes investing in emerging technologies that enhance customer experiences, such as virtual reality or personalized mobile apps.

A portion of the budget should be dedicated to marketing and promotion. Creating a budget for these activities is crucial to highlight the benefits of co-creation in tourism. This may involve traditional advertising channels as well as digital marketing efforts to reach a wider audience.

Risk management and mitigation should also be a consideration, with funds allocated to assess and mitigate potential risks associated with tourist co-creation. This may involve hiring risk management experts, conducting thorough market

research, and implementing strategies to prevent resource misalignment and customer dissatisfaction.

Educational initiatives are vital to ensuring tourists have the necessary information and knowledge for co-creation activities. Allocating resources for customer education initiatives may involve creating educational materials, conducting workshops, or collaborating with industry experts to provide guidance.

Investing in the design and enhancement of co-creation interfaces is crucial for a seamless experience. This includes allocating funds for skilled designers who can ensure that interfaces are user-friendly, visually appealing, and enhance the overall experiential fluency for tourists.

Market testing, pre-tests, and experiments are important to determine the optimum level of required tourist co-creation actions. Allocating funds for these activities may involve pilot programs, feedback sessions, and collaboration with focus groups to refine co-creation strategies.

Expanding the scope of co-creation contexts beyond pre-trip package-tour settings is essential. Allocating resources to explore co-creation opportunities during and after the trip, considering digital and on-site contexts, is crucial for long-term success.

Field experiments to establish a causal relationship between specific co-creation actions and business outcomes require a dedicated budget. This may involve partnerships with industry players, conducting on-site trials, and gathering data from real-world experiences.

Finally, investing in training programs and capacity building for tourism service providers and marketers is essential. This ensures they have the skills and knowledge to implement and manage co-creation processes effectively.

By strategically allocating resources to these areas, the tourism organization can support and enhance its co-creation initiatives while addressing the limitations highlighted in the research. This comprehensive finance and fundraising plan aims to position the organization for success in the competitive tourism market.

8. Conclusion

This plan challenges the prevailing belief in a straightforward positive linear relationship between tourist co-creation behaviors and tourism business performance. Instead, the findings reveal a nuanced, inverted U-shaped relationship between the degree of tourist co-creation and various tourism marketing performance indicators, including liking, participation, and recommendation intention. The research also introduces the concept of tourist experiential fluency as a moderating factor, showing its positive impact in mitigating the negative effects of excessive co-creation on marketing outcomes.

The theoretical contributions of this study are substantial, as it challenges the common assumption of an unequivocally positive linear relationship between tourist co-creation and marketing outcomes. By highlighting the potential for an inverted U-shaped relationship, the study underscores the need for a more nuanced understanding of the impact of co-creation on business performance. Moreover, the identification of tourist experiential fluency as a moderating factor enriches the theoretical framework, emphasizing the importance of cognitive processes in the co-creation context.

Practically, the study provides valuable insights for tourism marketers, cautioning against the possibility of value co-destruction in the pursuit of increased tourist co-creation. The suggestion to focus on tourist experiential fluency as a strategy to manage co-creation aligns with the call for informed decision-making by tourism practitioners. This study encourages a balanced approach, emphasizing the importance of optimizing, rather than maximizing, tourist co-creation for enhanced business outcomes.

Moving forward, there is a need for further exploration of potential moderators influencing the relationship between co-creation and business performance. Additionally, extending the scope of study beyond pre-trip package-tour settings to explore broader digital and on-site contexts during and after the trip will contribute to a more

comprehensive understanding of co-creation dynamics.

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Navigating Stakeholder Resistance in the Adoption of E-Health Innovations: Synthesis of Core Insights and Marketing Directions

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1. Consumer/user resistance is considered a key factor responsible for the failure of digital innovations. Yet, existing scholarship has not given it due attention while examining user responses to e-health innovations. The present study addressed this need by consolidating the existing findings to provide a platform to motivate future research. We used a systematic literature review (SLR) approach to identify and analyze the relevant literature. To execute the SLR, we first specified a stringent search protocol with specific inclusion and exclusion criteria to identify relevant studies. Thereafter, we undertook an in-depth analysis of 72 congruent studies, thus presenting a comprehensive structure of findings, gaps, and opportunities for future research. Specifically, we mapped the relevant literature to elucidate the nature and causes of resistance offered by three key constituent groups of the healthcare ecosystem—patients, healthcare organizational actors, and other stakeholders. Finally, based on the understanding acquired through our critical synthesis, we formulated a conceptual framework, classifying user resistance into micro, meso, and macro barriers which provide context to the interventions and strategies required to counter resistance and motivate adoption, continued usage, and positive recommendation intent. Being the first SLR in the area to present a multi-stakeholder perspective, our study offers fine-grained insights for hospital management, policymakers, and community leaders to develop an effective plan of action to overcome barriers that impede the diffusion of e-health innovations.

2. Introduction

E-health (or electronic health) technologies refer to various innovations that support the delivery of medical care and other healthcare services via the Internet or mobile apps. The key innovations in the healthcare space are mobile health applications (mHealth apps), web-based telemedicine services, health cloud, smart clothing systems, information technology-based assistive technology services, electronic medical record (EMR) systems, clinical decision support systems (CDSSs), RFID application in managing various forms of healthcare, and computerized physician/provider order entry (CPOE) (Barrett and Stephens, 2017, Bush et al., 2017, de Wit et al., 2019, Dubin et al., 2020).

The use of these innovations has been widely acknowledged to support diagnosis and improve the delivery of medical services. Over the years, digital technology-driven healthcare systems have become more potent, competent, fast, and beneficial in identifying illness and treatment (Kumari et al., 2018, Tanwar et al., 2020). In light of this, one would expect digitally delivered healthcare (e-health hereinafter) to become an integral part of the healthcare interface, beginning from e-consultation and ending with recovery through virtual care. However, until the beginning of 2020, this was not the case. Even in most advanced countries, e-health initiatives varying from telemedicine to CDSS have witnessed low diffusion due to resistance from multiple stakeholders, including patients, doctors, clinical staff, and hospital management. For instance, some reports note that in the United States, at the beginning of 2019, only a few healthcare systems had implemented virtual care (e.g., Mehrotra and Prewitt, 2019). However, things changed considerably with the surfacing of the COVID-19 crisis, particularly after the World Health Organization declared it a pandemic in March 2020 (Laato et al., 2020, Miri et al., 2020).

With a surge in infections and the consequent social distancing requirements, health systems across the globe made a massive move towards e-health technologies to provide virtual medical treatment (Webster, 2020). However, scholars have recently observed certain trends that do not bode well for plans for the long-term full-fledged shift of healthcare delivery through e-health systems. For instance, Webster (2020) noted that many doctors are still wary of e-health innovations, despite the pandemic. Others suggest that the care has already started shifting back to usual physical interactions (Mehrotra et al., 2020). This raises the question of whether the healthcare systems will relapse to their rather stiff adherence to the physical mode of consultation, treatment, and care once the pandemic recedes; or has the face of healthcare, as far as e-health is concerned, transformed forever?

The query is deceptively simple, but the answer is not easy to ascertain. The issue is not only of habit and adherence to a certain way of doing things. There are more intricacies involved. On the one hand, e-health systems offer benefits in the form of cost savings, expediency, and inclusiveness (e.g., Totten et al., 2019), but on the other hand, it is believed that these systems may not offer the quality of care that many doctors believe is possible only through physical interaction (e.g., Webster, 2020). Or is this just a matter of perception? Clearly, there is much to understand and evaluate. Indeed, with the healthcare sector as a whole being at crossroads, these aspects warrant deep contemplation and incisive insights such that the concerned stakeholders are able to strike the right balance, thereby benefitting the world through the expansion of e-health systems without compromising the quality of care.

The onus is now on academic research to shed light on varied embodiments, lineation patterns, and perceptions related to the adoption/non-adoption of e-health innovations such that the underlying dynamics, granularities, and complex nuances are better understood. We argue that to formulate a well-rounded response to the friction between the anticipated trajectory and unforeseen impediments in the way of diffusion of e-health innovations, it is essential to understand and address negative perceptions and barriers of the end-users, including doctors, patients, and hospitals. We further contend that to fully appreciate the potential inhibitors that might obstruct the diffusion of e-health innovations in times to come, it is essential to look back in the past to diagnose the factors that caused multiple stakeholders to resist these innovations before the onset of the pandemic, during the lockdown phase of the pandemic, and immediately after the lockdown restrictions were eased. In sum, there is a need to understand the consumer/user behavior of different stakeholders in the healthcare ecosystem to offer a clearer perspective on the future diffusion of e-health innovations.

A comprehensive review of the literature evolved through different phases of digitalization of healthcare, from healthcare 1.0 (1970 s), healthcare 2.0 (1991–2005), healthcare 3.0 (2006–2015) to healthcare 4.0 (since 2016) (Tanwar et al., 2020), reveals that although there is a reasonable volume of literature examining end-user perspectives, these studies have largely focused on adoption, considering non-adoption only as a by-product of the absence of adoption drivers. In comparison, studies focusing specifically on factors associated with the non-adoption of e-health innovations are limited. Since the extended literature suggests that non-adoption is not merely an outcome of the absence of factors that motivate adoption, rather it is a manifestation of consumer resistance (e.g., Talwar et al., 2020b), more research exclusively examining consumer resistance towards e-health innovations is required to guide practice better.

We suggest that to encourage future research addressing this specific requirement, there is a need to integrate the current knowledge, which is fragmented across narratives, creating theoretical confusion. In concordance, our study endeavors to synthesize the drivers of non-adoption of e-health innovations by different participants in the healthcare ecosystem. Towards this end, we propose to organize the state-of-the-art literature into meaningful clusters to structure the findings in a more relatable and reproducible way. In addition, we plan to bring forth the dilemmas, contradictions, and limitations in the existing knowledge to map future research needs. Specifically, we propose to address three research questions (RQs): RQ1. Why do multiple internal and external stakeholders resist e-health innovations across various healthcare contexts? RQ2. What are the methodological and

conceptual deficiencies in the extant literature that deprive practice of actionable insights? RQ3. What are the potential research paths that can meaningfully drive the future research agenda? We propose to use the systematic literature review (SLR) approach to address these research questions. Our choice of the SLR approach is based on past recommendations that it is an effective way of reviewing and synthesizing the identified literature (Dhir et al., 2020, Talwar et al., 2020b).

The unique contributions of our study may be summed as follows: (a) It is the first SLR in the area to review studies from the perspective of all key stakeholders—patients, doctors/clinical staff, hospital management, policymakers, and community leaders. By doing so we contribute to the theoretical deepening of the research in the area where discussion on consumer resistance have been rather operational so far; (b) it underscores the need to pay closer attention to the digital transformation dilemma, which poses many challenges despite the rhetorical emphasis on transitioning completely to a digital mode wherever possible; and (c) it scores due to its timeliness by raising the issue of resistance to e-health innovation when the world is settling in the new normal post-easing of the severity of the COVID-19 pandemic. Decisions taken now will determine the future of healthcare delivery and preparedness for meeting future health crises.

3. Marketing Analysis

To achieve the objective of our study and respond to the proposed research questions, we reviewed the state-of-the-art literature through a broadly accepted approach, i.e., an SLR (e.g., Christofi et al., 2021, Christofi et al., 2022). An SLR is a useful review approach since it enables researchers to review and report the existing findings systematically and extensively (Kaur et al., 2021, Seth et al., 2020). The inductive reasoning approach of an SLR offers established criteria for identifying the corpus of literature to be reviewed (Chaudhary et al., 2021, Kraus et al., 2022).

Although scholars have applied different steps to conduct SLRs, there is a common thread that can be observed across most of them. Following recently published SLRs (e.g., Bresciani et al., 2021, Madanaguli et al., 2022, we executed our study through the following steps: (i) setting the conceptual boundary of the review to serve as the basis for identifying the keywords and databases for the literature search, (ii) defining the study selection protocol through clear delineation of the inclusion and exclusion criteria, (iii) shortlisting of congruent studies through multiple rounds of screening, and (iv) reporting the review by undertaking a content analysis of the congruent studies to identify the key themes.

2.1. Setting the conceptual boundary of the review

The broad objective of our SLR is to review past studies examining resistance towards and the non-adoption of various e-health innovations envisaged to make the patient − hospital − doctor interface more information technology-driven. Accordingly, we identified the following initial set of keywords: healthcare information technology, resistance/non-adoption, patients, and doctors. Following the common practice, we searched this initial set of keywords on Google Scholar and thoroughly read the first 100 results. Based on the understanding developed from the analysis of these articles, we expanded the keywords list to 13. Thereafter, we sought the opinion of four experts (three professors and one practitioner) from information systems (IS), healthcare, and consumer behavior backgrounds to ensure that our keyword selection is comprehensive. They recommended two more words, resulting in the final list of 15 keywords, presented in Table 1. Finally, we identified two digital databases—Scopus and the Web of Science—to search and shortlist relevant studies for inclusion in the review. The choice of these two databases is guided by the fact that these have been acknowledged to be the most comprehensive indices of academic research by recent studies (e.g., Kaur et al., 2020).

Keywords related with innovations	Consumer resistance-related keywords	End user-related keywords
Healthcare information	Resistance	Consumer
e-health	Non-adoption	Doctor
Electronic health record		User
Health cloud		Patient
Health information technology		
Healthcare technology		
Health information management		
Medical informatics		
Telemedicine		

Table 1. Selected keywords.

Although we followed a very stringent process for the keyword selection and literature search, not all studies found through the search could be expected to be congruent with the topic at hand. Therefore, we also specified certain inclusion and exclusion criteria that could help us filter relevant studies. The criteria are presented in Table 2.

Inclusion criteria (IC)	Exclusion criteria (EC)
IC1. Articles published in peer-reviewed journal articles	EC1. Duplicate studies listed on both the databases identified through same digital object identifier (DOI)
IC2. Articles published in English	EC2. Articles published in other languages (other than English)
IC3. Articles focused on consumer resistance to digital innovations in the healthcare space	EC3. Articles on drug or any other type of resistance in medical terms
	EC4. Conference articles, review studies, student thesis papers, editorials, call for papers, magazine articles, and conceptual articles

Table 2. Inclusion and exclusion criteria for screening the studies.

We searched the identified keywords in the title, abstract, and author keywords using * and two Boolean operators: OR and AND. We used * with each of the keywords; OR was used within the category (keywords related to innovations, keywords related to consumer resistance, and the keywords related to end-users) and AND was used between the three categories. The search string was executed on both databases, setting the relevant time period as all years to date. The filtration process resulted in 154 potentially congruent articles after the reading of the abstracts.

To ensure a robust selection process for shortlisting articles for the SLR, we invited four researchers from the IS, healthcare, and consumer behavior fields to further evaluate our shortlist of 154 articles for their relevance to the topic at hand. At this stage, based on a consensus decision, the four evaluators generated a list of 82 articles to be included in the review. Next, guided by an expert team of three professors and one practitioner who had helped in keyword identification, the author team analyzed the full articles to arrive at a final list of 72 articles that were considered to be congruent with the conceptual boundaries of the present SLR.

4. Competitive Analysis

We analyzed the contents of the selected studies to understand and determine how the existing scholarship has evaluated resistance to e-health innovations from the point of view of different actors that constitute the complex healthcare sector. Given the scope of our review, we followed recent studies (e.g., Christofi, Pereira, et al., 2021) to analyze the shortlisted studies through a multistep qualitative coding approach. To begin with, we extracted the basic descriptive details of each study, including the author names, year of publication, product examined, country, theoretical framework, data collection approach/sample size, and method of data analysis. Curation of descriptive details not only revealed the research profile of the short-listed literature but also served as basis for identifying methodological gaps.

Thereafter, we analyzed the content of each study to distil the findings and discussions related to the sources of resistance. Herein, each author coded the data independently. We used MAXQDA to perform the analysis and coding process as it offers a versatile environment for this purpose. To ensure inter-coder reliability, after each round of coding, the authors discussed the codes and resolved the dissensions and issues. Since the stated objective of our review study was to synthesize the literature from the perspective of diverse stakeholders, the key point of discussion was how the perspectives would be presented. The choices were to coagulate the clusters based on theories used, underlying disease discussed, methodology used, the geography of data collection, variables examined, and stakeholders examined. After much debate and advice from our expert panel of three professors and one practitioner who had helped in the keyword identification and study selection, the consensus decision was to present the literature by clustering it simply from each separate stakeholder perspective. The choice was primarily driven by the fact that literature organized from the perspective of the consumer behavior of each type of stakeholder separately would provide a logical and relatable context for the theoretical advancement of research in the area. As a result, the author team decided to cluster the findings from the individual perspective on the one hand and the organizational perspective on the other.

A comprehensive review of the full text of the shortlisted studies also made us realize that individual perspectives should be evaluated from the patients' point of view because the studies related to healthcare professionals had a distinct organizational slant covering stakeholders such as physicians, surgeons, nursing staff, technicians, information technology experts, administrators, and management. As a result, we identified patient resistance as one thematic cluster and organizational resistance as another thematic cluster. In addition, based on the studies that distinctly focused on a multi-stakeholder perspective by examining the resistance of a variety of internal and external stakeholders towards a given innovation, we identified a third thematic cluster, that of multi-stakeholder resistance to e-health innovations. Accordingly, the following thematic clusters, as presented in Fig. 1, were identified: (a) patients' resistance to e-health innovations, (b) organizational resistance to e-health innovations, and (c) multi-stakeholder resistance to e-health innovations.

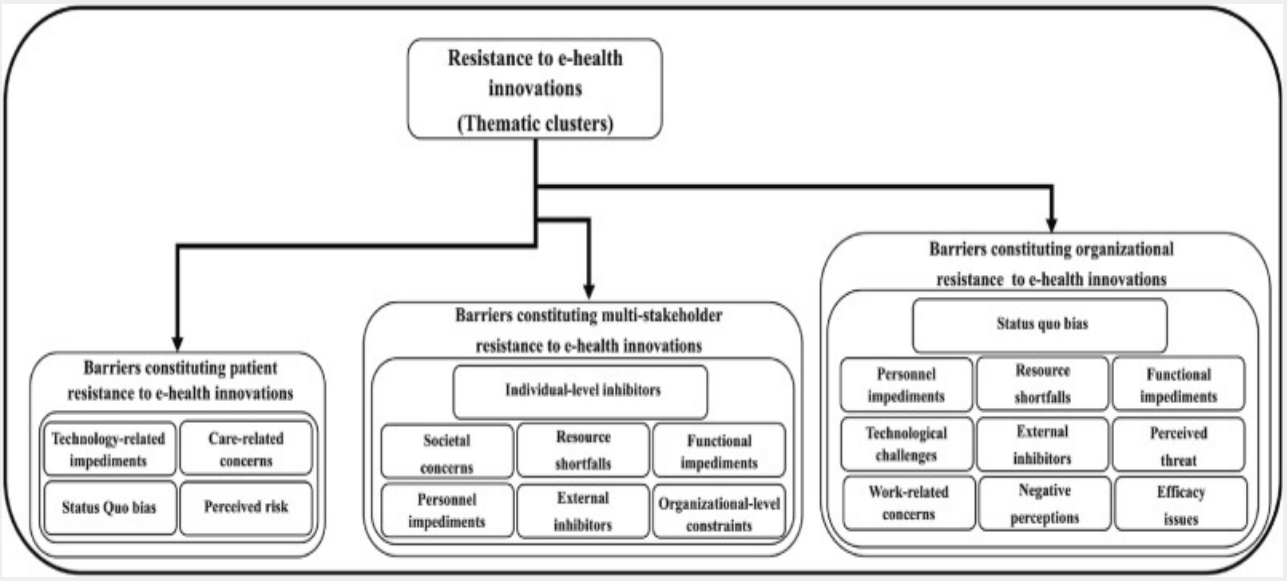

Fig. 1. Thematic Clusters.

4.1 Patients' resistance to e-health innovations

With the advancement of information and communication technology (ICT), the healthcare sector has also seen a shift in the mode of interaction between patients and healthcare providers, leading to the concept of electronic healthcare or e-healthcare. As such, the use of the internet and the underlying technology to provide consultations, monitor patient health, maintain patient records, and so on is called e-health (Bhatnagar et al., 2017). In general, scholars have considered various dimensions of patients' responses to e-health innovations. Specifically, past studies have examined patients in both developed and developing economies to diagnose the guarded and rather unenthusiastic response to e-health innovations, despite their being effective in improving access to healthcare at a reasonable cost. To this end, prior studies have employed both qualitative and quantitative research designs to collect the required data. A total of 14 studies selected for our review have examined patients' perspectives, of which 11 have used a quantitative research design, two have used a qualitative design, and one has used mixed-method design.

These studies have examined e-health interfaces such as mobile health apps (Alaiad et al., 2019), mobile health services (mHealth) (Cao et al., 2020, Deng et al., 2014, Hoque and Sorwar, 2017, Mikolasek et al., 2018), and so on. Scholars have discussed not only the factors that have driven the adoption of these services but also the factors that cause patients to resist them. In doing so, the selected studies have used technology acceptance theories such as the unified theory of acceptance and use of technology (UTAUT; e.g., Alaiad, 2019; Hoque and Sorwar, 2017, Hsieh, 2016) and the technology acceptance theory (TAM; e.g., Cranen, 2011; Kamal et al., 2020; Tsai et al., 2019; Tsai et al., 2020;) amongst others, as presented in the table in Appendix I.

In discussing sources of resistance directly, or making an indirect reference to them, existing scholarship has identified technology anxiety, security and privacy risk, resistance to change, sunk costs, inertia, perceived value, transition costs, and uncertainty as the key factors that can impede the adoption of e-health innovations by patients (Alaiad 2019; Hoque and Sorwar, 2017, Hsieh, 2016). In addition, some studies examined and confirmed the role of socio-demographic attributes in shaping patients' resistance towards e-health innovations. For example, Deng et al. (2014) found that resistance to change was a key dissuading factor for middle-aged patients, whereas for older users it was technology anxiety. Similarly, Cao et al. (2020) revealed that information overload and system feature overload in mHealth applications contributed to resistance of elderly patients by increasing fatigue and technostress.

In one of the limited efforts to examine barriers to e-health innovation adoption (with reference to

telemedicine, specifically), Zobair et al. (2020) revealed lack of organizational effectiveness, motivation of health staff, satisfaction among patients, and trustworthiness as the key barriers. In a similar vein, Kamal et al. (2020) revealed technological anxiety, perceived risk, and resistance to technology as key barriers towards e-health innovations. Tsai et al. (2020) reported similar results in the case of a smart clothing system, revealing technology anxiety to be a key barrier.

We summarize the sources of resistance noted by each of the 14 studies to consolidate them under four broad headings: (i) technology-related impediments, (ii) care-related concerns, (iii) status quo bias, and (iv) perceived risks, as presented in Fig. 1. The technology-related impediments comprise factors such as technology anxiety, resistance to technology, lack of technical competence, lack of ability to operate equipment, low computer self-efficacy, and fears of disruption of services. The care-related concerns of patients were manifested through lack of satisfaction with the diagnosis and treatment suggested, lack of trust in organizational effectiveness, and concerns related to the lack of healthcare staff motivation. Next, status quo bias of patients was manifested through resistance to change, inertia, and transition cost. Finally, perceived risks comprised sources of resistance such as uncertainty, security, privacy, lack of trust, threat to identity, information overload, system feature overload, fatigue, and technostress.

4.2. Organizational resistance to e-health innovations

Scholars have been mindful of the resistance offered by doctors, clinical staff, and other organizational stakeholders, as evidenced from a reasonable body of extant literature examining their opposition to the adoption and use of e-health systems. For instance, Bhattacherjee and Hikmet (2007) underscored the importance of recognizing and examining user resistance to technology in the specific case of e-health innovations. Lin et al. (2012) also contented that understanding the resistance perspective is important to better diagnose technology rejection. These and other studies examining the resistance of healthcare professionals and other organizational stakeholders to e-health innovations have employed both qualitative and quantitative research designs to collect the required data. A total of 46 studies selected for our review have examined the organizational stakeholders' perspective, of which 20 have used a quantitative and 26 have used a qualitative research design.

These studies have focused on a variety of products, deploying theoretical frameworks used by scholars for examining consumer behavior in different contexts. Some of the predominant aspects of these studies include the following: (a) recognition of the fact that resistance to e-health innovations varies with the type of professionals/organizational stakeholders under discussion, such as physicians versus nurses (e.g., Barrett, 2017); (b) the importance of considering both pre- and post-implementation challenges and engagement, especially since less-engaged groups may develop resistance. Such groups are more likely to use unsanctioned workarounds if they perceive the given system to be inadequate (e.g., Bagot et al., 2020, Cresswell et al., 2017); (c) the importance of workarounds that may lower resistance to change (e.g., Barrett & Stephens, 2017); (d) the role of resistance in lowering adoption-related factors such as perceived usefulness (e.g., Beglaryan et al., 2017); (e) the difference in user versus non-user perceptions of barriers and related solutions from an administrative perspective (e.g., Zandieh et al., 2008); and (f) acceptance of the fact that despite its acknowledged potential to improve the quality of healthcare, health information technology has diffused quite slowly since its introduction in the 1980s (Grabenbauer et al., 2011).

Within these broad boundaries, the e-health products/services examined include electronic health records (e.g., Al-Rayes et al., 2019, Grabenbauer et al., 2011, Heath and Porter, 2019, Hossain et al., 2019, Ngafeeson and Manga, 2021), clinical decision support systems (e.g., Fossum et al., 2011, Litvin et al., 2012, Zakane et al., 2014), etc., presented in the table in Appendix II. The key theories utilized by these studies are the acceptance/adoption theories, such as the technology acceptance model (e.g., Al-Rayes et al., 2019, Bezboruah et al., 2014, Segrelles-Calvo et al., 2017), the unified theory of acceptance and use of technology (e.g., Bush et al., 2017, Hossain et al., 2019), and so on, as presented in the table in Appendix II. In addition to the acceptance perspective, some scholars have provided insights

about change management and personnel issues related to the use of e-health innovations by a wide range of professionals, such as physicians, surgeons, technicians, ancillary staff, nurses, physiotherapists, administrators, and other organizational stakeholders (Barrett and Stephens, 2017, Bush et al., 2017, Kelly et al., 2017, Lapointe and Rivard, 2005, Segrelles-Calvo et al., 2017). To this end, they used theories such as the theory of interpersonal influence and leadership (Ilie & Turel, 2020) and so on, as presented in the table in Appendix II. A limited number of studies have utilized resistance theories and perspectives, such as the psychological reactance theory (Ngafeeson & Manga, 2021), status quo bias (Hsieh, 2015, Hsieh and Lin, 2020) and the theory of innovation resistance (de Wit et al., 2019) to specifically focus on the barriers that drive resistance of healthcare professionals and other organizational stakeholders towards the use of e-health innovations.

Using these theoretical frameworks, the reviewed studies revealed resistance to change brought by the introduction of e-health innovations to be a key driver of resistance towards a given innovation (Al-Rayes et al., 2019, Bhattacherjee and Hikmet, 2007, Barrett and Stephens, 2017, Dubin et al., 2020, McAlearney et al., 2013). Such resistance could be related to changes in workflow and organizational impediments or control concerns (Grabenbauer et al., 2011, Kelly et al., 2017, Litvin et al., 2012, Stronge et al., 2008). Workflow issues may arise if the innovation is not integrated within the existing workflow, requiring the concerned professional to spend additional time to get the work done or increasing the documentation requirement, resulting in productivity losses (McAlearney et al., 2013, Ser et al., 2014, Yu et al., 2013).

Institutional politics may also impede the diffusion and use of these innovations (Ackerman et al., 2012). In addition, institutional pressures, the unsystematic process followed by management for technology adoption, information asymmetry, and issues in communication can also cause resistance (e.g., Bezboruah et al., 2014).

Over and above this, many studies have noted the impact of technical complexities and technical capabilities on resistance towards the use of e-health innovations (Aboelmaged and Hashem, 2018, de Wit et al., 2019, Segrelles-Calvo et al., 2017), which can lead to aggravation due to lack of training (Hossain et al., 2019, Ser et al., 2014). Anxiety among healthcare staff about delivering proper patient care with a new technology, which is driven by self-doubt about their own technical competence, skills, and knowledge, also acts as dissuading factor (Jindal et al., 2018, Taylor et al., 2015).

Overall, the extant findings have reinforced the barriers associated with innovation implementation in general, such as the need for technical support, worries related to technology, perceived threat, perceived risk, cost barriers, user resistance, culture, and the disruption of work routines that have been discussed by the reviewed studies (e.g., Bush et al., 2017, Caffery et al., 2017, Cocosila and Archer, 2016, Hsieh, 2015, Lin et al., 2012, Varsi et al., 2015), as presented in Appendix II.

We summarize the sources of resistance noted by each of these 46 studies to consolidate them under 10 broad headings: (i) personnel impediments, (ii) resource shortfalls, (iii) functional impediments, (iv) technological challenges, (v) external inhibitors, (vi) perceived threats, (vii) work-related concerns, (viii) negative perceptions, (ix) efficacy issues, and (x) status quo bias, as presented in Fig. 2.

4.3. Multi-stakeholder perspectives on resistance to e-health innovations

The diffusion of e-health innovations has been challenging because the resistance to their adoption and subsequent use comes from multiple stakeholders at the same time. This implies that every innovation that comes up as an alternative for digitalizing a process or interface encounters barriers from patients, healthcare professionals, administrators, and management concurrently. Thus, resistance is actually a complex outcome of multiple inhibitors perceived by varied stakeholders in the same temporal context. Some scholars, albeit few, have recognized this fact and investigated resistance to a given e-health innovation from the perspective of multiple stakeholders such as patients, physicians, IT staff, nursing staff, consultants, pharmacists, social workers, administration staff, hospital directors, and so on. These studies have employed both qualitative and quantitative research designs to collect the required data. A total of 12 studies selected for our review have examined

multi-stakeholder perspectives, of which two used a quantitative research design, nine used a qualitative research design, and one used a mixed-method design. The key findings in this regard are that the level of resistance varies with stakeholder type (e.g., Alajlani and Clarke, 2013, Safi et al., 2018, Wang et al., 2015) as well as with the demographic profile of the respondent (e.g., Alajlani and Clarke, 2013, Poss-Doering et al., 2018, Weitzman et al., 2009).

These broad findings are based on the examination of resistance offered to innovations such as electronic health records (Poss-Doering et al., 2018, Takian et al., 2012), electronic patient-reported outcome mobile application and portal systems (Hans et al., 2018), etc. as presented in Appendix III. The reviewed studies have drawn upon different theoretical frameworks to provide insights about factors that drive the resistance of the internal and external stakeholders to e-health innovations. The key theories utilized are the healthcare information systems evaluation Framework (Wang et al., 2015) and the technology acceptance model (Safi et al., 2018, Wang et al., 2015), amongst others.

Examining resistance from a multi-stakeholder perspective enabled the past studies to identify varied dimensions of such resistance such as societal, interpersonal, and individual. Some of the key drivers include integrity, prioritizing health information technology to advance healthcare and policy issues, discomfort and unwillingness of providers to share power and information, lack of technological literacy and low self-efficacy to use the innovation, less commitment to collaborative work, organizational complexity, and lack of conducive organizational culture (Serrano et al., 2020, Weitzman et al., 2009).

As observed in the case of the individual as well as the organizational perspective, the lack of technological skills and knowledge at both patient and organizational levels has continued to manifest during the past decade (Campling et al., 2017, Cijvat et al., 2021, Takian et al., 2012, Weitzman et al., 2009). Furthermore, different stakeholders tend to have different levels of concerns related to privacy protection, with fear of misuse being highest in doctors (Wang et al., 2015). The financial aspect has also been underscored as a reason behind resistance to e-health innovations (Alajlani and Clarke, 2013, Campling et al., 2017, Poss-Doering et al., 2018, Serrano et al., 2020). In addition, data safety and security serve as barriers that drive the resistance of multiple stakeholders to accept/adopt/use e-health innovations (Alrahbi, Khan, Gupta, Modgil, & Chiappetta Jabbour, 2022, Poss-Doering et al., 2018, Wang et al., 2015). Cost and usability are also important considerations for organizational stakeholders, along with concern for patient care (Alrahbi, Khan, Gupta, Modgil, & Chiappetta Jabbour, 2022, Choi et al., 2019).

Organizational level issues such as power-sharing, management control, disruption in workflow, liability concerns, and impact on the relationship with patients are also seen as key sources of resistance offered by professionals to e-health innovations (Hans et al., 2018, Safi et al., 2018, Takian et al., 2012, Weitzman et al., 2009). In fact, of the key stakeholders, including policy-making officials, healthcare professionals, patients, and industrialists, healthcare professionals emerged as the most resistant group (Choi et al., 2019), with stakeholders responsible for governance and policy-making identifying the highest number of barriers (Serrano et al., 2020).

In sum, as presented in Appendix III, technological concerns, financial aspects, and organizational issues are the key sources of resistance to e-health innovations when seen from a multi-stakeholder perspective. We further organized these barriers under seven broad categories to present an aggregate view of multi-stakeholder resistance, as presented in Fig. 2. The key categories are (i) societal concerns, (ii) resource shortfalls, (iii) functional impediments, (iv) personnel impediments, (v) external inhibitors, (vi) organizational-level constraints, and (vii) individual-level inhibitors.

After establishing the exigency of advancing research on the resistance to e-health innovations, we sought to address three research questions (RQs). To respond to RQ1, we analyzed the short-listed studies to develop a comprehensive set of drivers of resistance from the perspective of three user groups: patients, organizational actors, and multiple internal and external stakeholders. The results are discussed in detail in the preceding text and are also presented through Fig. 1. Overall, it is

rather surprising that the studies published a decade back as well as those more recently have noted technology-related, training-related, and usability-related issues among the key reasons behind the resistance of healthcare professionals and other organizational stakeholders towards e-health innovations (Hoonakker et al., 2013, Ser et al., 2014, Stronge et al., 2008). The fact that, even after more than a decade, not much progress has been made to address the technology-related issues points to the need for more intensive efforts to overcome resistance. Offering a solution, the existing scholarship in the area argues that the resistance manifested by healthcare professionals and other organizational stakeholders in the form of distrust, inertia, reactance, and so on (Ngafeeson & Manga, 2021) can be countered by organizations by honestly communicating the anticipated obstacles and associated benefits during the initial implementation phase of these innovations (Barrett, 2017) and using workarounds to reduce resistance to change (Barrett & Stephens, 2017). At the same time, scholars caution against using interpersonal influence tactics judiciously since, in some cases, they may actually end up unintentionally increasing resistance (Ilie & Turel, 2020). Succinctly, research in this area needs to expand in volume and mature in coverage to make agenda-setting contributions to practice.

To respond to RQ2, we critically analyzed the short-listed studies to identify methodological and conceptual deficiencies in the extant literature that deprive practice of actionable insights. To begin with, in the case of all three resistant perspectives—patient, organizational stakeholder, and multi-stakeholder—there is a similar kind of methodological shallowness and linearity-spanning limitations in methods of data collection, geographies sampled, and data analysis methods applied. There are three key gaps in this regard.

(i) Methods of data collection: If we consider the total sample of 72 studies, then there is an appreciable balance between the quantitative and qualitative insights available on resistance to e-health innovations. However, if we consider the individual thematic clusters, then in the case of the patients' perspective, of the 14 congruent studies selected for our review, 11 have used a quantitative research design, two have used a qualitative design, and one has used a mixed-method design, indicating not only very limited but also skewed findings. In contrast, in the case of multi-stakeholder perspective, of 12 congruent studies reviewed, only two have used a quantitative approach, with nine offering qualitative insights and one using a mixed-method design, again indicating a narrow and skewed literature base, but on the opposite side in this case. Admittedly, there is a balance in available insights with regard to studies examining the organizational perspective (46 studies of which 20 have used a quantitative and 26 have used a qualitative research design).

Within these broad design-based limitations, the methodology used lacks variety, with most quantitative studies employing a paper and/or web-based, self-reported, single-wave, questionnaire survey for empirical data collection. In comparison, very few studies have employed an experimental design or collected data in multiple waves. In the case of qualitative design, most studies have used focus groups and semi-structured interview approaches. In comparison, other qualitative approaches, such as open-ended written essays, observation studies, diary studies, and so on have hardly been employed. Since the data collected and analyzed forms an important part of robust research, there is a need to address these gaps by expanding the repertoire of methodological tools used by researchers.

(ii) Geographies sampled: Most of the studies reviewed from all three perspectives have either focused on an Asian country such as China, Taiwan, Bangladesh, and Pakistan, or on the United States, with some studies examining advanced economies in Europe. As a result, the literature presents skewed findings with limited generalizability. The focus on the US is particularly intriguing, given that, anecdotally, technology resistance has been considered to be a characteristic of emerging and under-developed countries. The reason behind the narrow geographical focus could perhaps be that the US has been at the forefront in introducing e-health innovations, thereby providing suitable field conditions for the studies to take place. Regardless, this serves as an indication that future researchers need to focus on different geographies with an unbiased preconceived notion about technology

resistance being rooted only in the level of development.

(iii) Data analysis methods applied: As mentioned above, the reviewed studies have used both qualitative and quantitative data to respond to their identified research questions. The collected quantitative data has been analyzed largely using common data analysis methods such as hierarchical regression analysis, covariance-based structural equation modeling, and variance-based structural equation modeling, amongst others mentioned in Appendices I through III. These are popular yet common methods of data analysis that do not provide advanced insights. This severely limits the width and depth of findings at the disposal of researchers and practitioners endeavoring to develop models and strategies to overcome resistance to innovations. In comparison, the studies based on qualitative data collection have analyzed the data using a variety of methods such as content analysis, narrative analysis, framework analysis, grounded theory approach, and interpretive phenomenological analysis. The preceding discussion indicates that there exists much scope for increasing the methodological width of the literature in the area.

In terms of gaps from a conceptual perspective, we observe that in the case of all three resistant groups—patients, organizational stakeholders, and multi-stakeholders—existing scholarship has adhered to a rather narrow conceptualization by examining a limited set of e-health innovations, employing commonly used acceptance theories and focusing on a comparatively narrow set of respondents in terms of both variety and number. The key gaps in this regard are as follows:

(i) The limited set of e-health innovations examined: A limited variety of innovations have been examined, with most studies focusing on a clinical decision support systems (four), computerized physician/provider order entry systems (three), electronic health/medical records (18), tele-health /telemedicine (15), and mHealth interventions/services/apps (seven). Unless the understanding of the drivers of resistance to a wider variety of innovations is clear, it will be difficult for academic research to offer viable strategies for the commercial success of these innovations in a way that the community also benefits.

(ii) The limited set of user groups/activities examined: A close look at the reviewed literature as presented in Appendices I through III and in comparison to the extensive universe of patients, providers, clinicians, IT staff, administrators, and types of healthcare set-ups reveals that what has been examined is really the tip of the iceberg. Thus, the existing literature is considerably constrained and limited in providing the real picture of resistance as it exists on the ground.

(iii) Limited theoretical frameworks utilized: As evident from the preceding discussion and Appendices I through III, the existing scholarship has shown a predominant tendency to use acceptance/adoption theories like TAM, UTAUT, and TPB to examine the resistance offered to e-health innovation. Since prior literature has clearly established that the drivers of adoption are quite distinct from those of resistance, the use of the acceptance lens perhaps weakens the robustness of the resistance-related insights offered by these studies.

(iv) The limited scope of inquiry: The extant literature has examined a variety of variables; however, resistance has been investigated by most of these studies as an afterthought rather than as a key point of focus. Due to this, the understanding of finer aspects of resistance to e-health innovations in terms of its type (i.e., postponement, opposition, or rejection) or form of its manifestation (active or passive) has been quite deficient so far.

We responded to RQ3 by putting forth tangible recommendations for setting a future research agenda. Herein, we have formulated a conceptual framework and proposed potential research questions grounded in the framework to provide future researchers a comprehensive frame of reference. The framework and the potential research questions are discussed in detail below.

5. Product Design

Building upon the theoretical insights obtained from our literature review, we propose a conceptual framework. The proposed framework embodies a comprehensive view of resistance of multiple stakeholders towards the adoption and continued usage of e-health innovations. The proposed

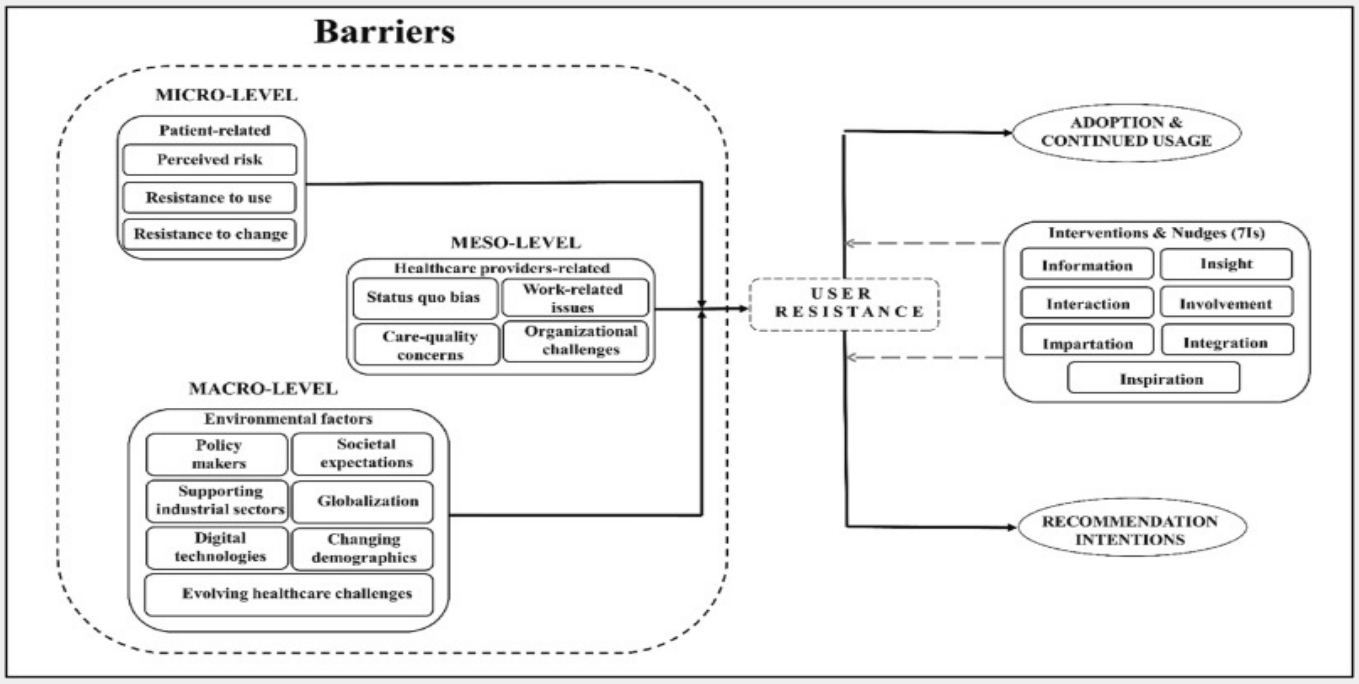

Fig. 2. Conceptual Framework.

framework goes beyond mere mapping of drivers of resistance to highlight various nudges and interventions that can be leveraged to overcome resistance, thereby increasing adoption, post-adoption usage, and recommendation intent. In sum, our framework rests on the tripod of (i) barriers and user resistance, (ii) consequents, and (iii) nudges and interventions, as presented in Fig. 2.

(i) Barriers and user resistance: We have categorized the barriers under three levels—micro, meso, and macro—as per user groups. The mapping of levels to user groups provides a rational context for presenting commensurate and relevant interventions. We have categorized barriers at these three levels by drawing upon Chandler and Vargo's (2011) conceptualization, which was extended by Beirão et al. (2017) to examine the healthcare service ecosystem. Accordingly, the barriers/sources of resistance at these three levels are discussed below.

Micro-level barriers are drivers of resistance of individual actors represented by patients. We identified barriers under this category on the basis of an understanding evolved from our review of congruent studies, as discussed under thematic analysis and presented in Appendices I and III. For the ease and clarity of presentation, we have classified these barriers under three broad headings: (a) resistance to change, (b) resistance to use, and (c) perceived risk.

Resistance to change captures patients' tendency to avoid e-health innovations due to inertia, concerns about transition costs both in terms of learning effort and monetary expense, comfort with existing practices, inaccurate perceptions about the efficacy of these innovations, and care-related concerns. Succinctly, resistance to change represents patients' status quo bias. In comparison, resistance to use represents a set of micro-level barriers that arise from patients' technology anxiety, limited computer self-efficacy, and concerns about fatigue and technostress due to information and system feature overloads. In essence, these factors capture the dark side of technology use and self-doubt about using it efficaciously. Finally, perceived risk, representing the third broad set of micro-level barriers, encapsulates resistance arising from patients' perception of threat to identity, privacy concerns, data security worries, and lack of trust.

Meso-level barriers are drivers of resistance of organizational actors such as healthcare professionals, technicians, administrative staff, and management. We shortlisted barriers under this category by consolidating our understanding derived from the reviewed studies, as discussed in the thematic analysis. To put forth a structured and

reproducible map, we have classified the meso-level barriers under four broad headings: (a) status quo bias, (b) work-related issues, (c) care-quality concerns, and (d) organizational challenges.

Status quo bias represents a set of barriers perceived/manifested by the healthcare providers at an individual level, but in the workplace setting. These barriers include preconceived notions against the said innovation, task-fit issues, low involvement in implementation, perceived helplessness, low perceived value of change, differences in personal innovativeness, and stress on account of change.

Next, work-related issues that may cause resistance from organizational actors encompass a set of factors that includes increased workload, time commitments, changes in workflow, higher documentation burdens, role ambiguity, fear of legal and medical liability, and reduction in autonomy. In the case of care-quality concerns, the meso-level barriers mainly manifest on account of worries related to assessing patient suitability, impact of the system on patients' anxiety, dehumanization of the patient-provider relationship, commercial exploitation of patients, too much standardization of the medical decision-making process, inability to provide the desired patient care, fear of self-medication or treatment leading to patient isolation, misfit of new technology with logic of care, and lack of clarity about operational and practical aspects of patient care and management.

Coming to organizational challenges, the resistance of healthcare providers may manifest due to lack of training, limited clinical knowledge, low engagement levels of staff, decreased productivity, lack of required routines, communication problems, unplanned and ineffective implementation, limited resources leading to infrastructural shortages, technology usability challenges, design and software barriers, issues in integration with other IT systems, fears associated with system efficacy or performance risk, and doubts about the clinical and cost effectiveness of the system.

Macro-level barriers are drivers of resistance coming from the milieu in which the healthcare sector operates. These barriers can arise on account of (a) policy makers, (b) societal concerns, (c) supporting industrial sectors, (d) globalization, (e) the nature of digital technologies, (f) changing demographics, and (g) evolving healthcare challenges. In other words, the politico-administrative actors, national orientation, socio-demographic profile of the population, regulatory expectations, level of economic development, technological ability and know-how, technology transfer and support systems, and tertiary support of related industrial sectors can all play an important role in driving resistance towards e-health innovations.

Coming to specific details, the barriers attributable to policy makers include regulatory enforcement to implement a system, policy confusion, and the general lack of a supportive environment. Next, societal concerns that hinder the unobstructed diffusion of these innovation span a variety of data, integrity, compensation, information, and societal-awareness barriers. Lack of support from tertiary industrial sectors, vendor-related issues, coordination problems, complex supply routes, and other external factors also act to inhibit the adoption and continued usage of these innovations. In addition, the lowering of sovereign boundaries, the fast-paced transition and transformation of digital technologies, aging populations—particularly in lower- and middle-income group countries where healthcare affordability and reach are a challenge—and the rising complexities of healthcare systems also act, covertly but quite detrimentally, as barriers.

(ii) Consequents: We propose adoption, continued usage, and recommendation intentions as the three outcome variables of interest, implying that, ultimately, future research should examine how the user resistance towards e-health innovations can be countered to increase adoption and to ensure continued usage. To elaborate, from the perspective of individual patients, the key consequents could be their willingness to consult, continue treatment, and receive care virtually when required, as well as comply with all information sharing and safety requirements that can support the frictionless use of e-health technologies. In the case of the organizational actors, adoption and continued usage would imply sincere implementation of the e-health technologies for delivering healthcare, committing adequate resources, and avoiding unfaithful workarounds that may reduce the efficacy of the

implemented systems. From the perspective of macro actors such as regulators and policy makers, this would imply the formulation of clear policy guidelines and the creation of a conducive environment for the expedient yet voluntary adoption of these technologies by the concerned user groups.

In addition to proposing adoption and continued usage as outcome variables of interest, we have also included recommendation intentions in our framework, since word of mouth and its effect on users' adoption behavior is well-documented in the consumer behavior literature (Talwar et al., 2020a, Talwar et al., 2021).

(iii) Nudges and interventions: The role of nudges and interventions in inducing individuals to act in a societally or environmentally desirable way is well-established in the literature (Dhir et al., 2020). In addition, prior literature on resistance to digital innovations, in general, has also discussed how interventions in the form of information and guidance (Talwar et al., 2020b) can lower resistance. Furthermore, the idea that resistance from key stakeholders can be overcome through well-defined strategies is also consistent with the seminal work of Ram and Sheth (1989) in which several marketing strategies were discussed to overcome customer resistance to innovations.

In the present context, we propose seven Is to represent different kinds of interventions and nudges that can be used to counter resistance of different user groups. For instance, information shared through mass media promotion may work well to reduce the patients' resistance. Similarly, insights shared through workshops, seminars, and reading material may help healthcare professionals know more about the available innovations and their usefulness. At the same time, continuous engagement and communication may work well for organizational actors to handle their anxieties and concerns in the pre-implementation stage. Continued interaction with the external stakeholders, such as regulators, suppliers, and societal representatives, can also serve as a nudge and intervention for ensuring that the macro-level barriers are mitigated. Also, involvement in the decision making and seeking feedback from user groups may serve to lower their resistance before it escalates into complete rejection. From the organizational perspective, training diligently, integrating the workflow and routines of healthcare professionals and staff, and motivating them through additional compensation and recognition can also nudge them in the right direction to use the system faithfully and efficiently. Bringing it all together, we suggest that more such nudges and interventions should be designed and implemented through an approach similar to planned social change driven by reinforcement, inducement, rationalization, and confrontation, as discussed by Sheth and Frazier (1982).

6. Marketing Plan

Our study contributes to the accumulated literature on resistance to e-health innovations in the following three ways. First, our review builds upon and addresses the limitations of the prior reviews on the topic by offering a broader and deeper view of resistance to e-health innovations that incorporates the perspectives of all key stakeholders, covering varied geographies and a variety of e-health innovations. An examination of prior reviews reveals their narrow scope in terms of the coverage of stakeholders, innovations, and geographies. For instance, Almathami et al. (2020) reviewed congruent studies to identify the barriers and facilitators that impede or stimulate the adoption of healthcare home consultation systems, and Niazkhani et al. (2020) identified various barriers that hinder the adoption of electronic personal health records by patients, caregivers, and providers. Similarly, Kumar et al. (2020) examined the pertinent corpus of studies published in information system journals and conferences to present a consolidated view of resistance to healthcare information technology focusing on the interactions of people, practice, and technology. Adding to the growing volume of review literature, Al-Samarraie et al. (2020) analyzed relevant studies to reveal insufficient progress made in the diffusion of telemedicine in Middle Eastern countries, identifying many key challenges such as financial, cultural, and regulatory. Relatively older studies have also shown a similar narrow inclination toward reviewing studies on resistance by remaining confined in terms of publications, user groups, or innovations. For example, Davidson et al. (2018) reviewed the evolution of healthcare research in information system journals since 2004, offering a

descriptive narrative of the accumulated findings through three clusters: health information technology adoption and diffusion, physician resistance to health information technology use, and the impact of health information technology on healthcare outcomes, and Kruse et al. (2018) mapped the barriers inhibiting the adoption of telemedicine across the world by reviewing the existing research. In a similar vein, Kruse et al. (2015) conducted an SLR to uncover the drivers of resistance of patients and providers to patient portals, and Lluch (2011) reviewed studies on healthcare professionals' organizational barriers to health information technologies. The review offered a single perspective and categorized the barriers into five categories from the organizational viewpoint. In another noteworthy review, Boonstra and Broekhuis (2010) synthesized studies specifically examining physicians' barriers toward the adoption of electronic medical records. In comparison, the broad coverage of our study provides an integrated view of resistance of different end-users towards e-health innovations, presenting a single point of reference for researchers.

Second, our study lucidly categorizes the resistance literature under three clear perspectives based on user groups: (a) patients, (b) organizations (an umbrella term for physicians, nurses, administrators, technicians, and hospital directors) and (c) multiple other internal and external stakeholders. Such categorization helps synthesize the literature in a more relatable and understandable manner, making it a useful reference for future research and ongoing practice. Our theoretical contribution is further concretized by two key aspects of our study: (i) we have presented a clear narrative of the underlying products, theories, methodologies, and barriers for each user cluster (see Appendices I through III), and (ii) we have specifically summarized the sources of resistance discussed/revealed by each study, offering a comprehensive narrative to balance the literature that has so far majorly focused on adoption, referring to resistance almost as an afterthought. Such summarization is quite valuable, especially in the cases where barriers are not immediately apparent.

Finally, our explicit delineation of methodological and conceptual underpinnings of resistance serves as a coherent basis for suggesting well-defined PRQs for the academic community to work on. By doing so, we bring forth potential areas of research that could not only enrich the insights specific to resistance towards e-health innovations but also contribute to the richness of the methodological literature in general. To make our contribution even more tangible, we have formulated a conceptual framework that brings together potential research paths, serving as a ready reference for researchers keen to advance the academic understanding of the resistance of multiple stakeholders, manifested through rationally experienced or irrationally perceived barriers. Succinctly, our proposed framework comprising barriers classified into micro-, meso-, and macro-categories can help theorists and practitioners evolve more contextual strategies. At the same time, our detailed presentation of methodology-related gaps can provide future researchers with valuable inputs on how to determine a suitable research design and plan better theory-based conceptualizations. For instance, our study suggests that future researchers should consciously draw upon the resistance-related theories such as innovation resistance theory (IRT; Ram & Sheth, 1989) and status quo bias theory (SQB; Samuelson & Zeckhauser, 1988) to formulate models theorizing and testing more resistance-related variables, rather than explaining resistance as the absence of adoption drivers. Recent studies have deployed these theories effectively to explain consumer resistance in different contexts (e.g., Khalil et al., 2023).

Our study offers three key contributions for practice: First, our study reveals that resistance to e-health innovations is not confined to patients or doctors alone, rather multiple internal and external stakeholders who can play a vital role in supporting the adoption of these innovations also have reservations about their efficacy, utility, and implementability (Campling et al., 2017, Choi et al., 2019, Takian et al., 2012). By uncovering such finer dimensions, we bring out the complexity of the issue and provide useful inputs for formulating effective strategies and interventions to overcome such resistance.

Second, we highlight the fact that despite the potential of these innovations to deliver healthcare more efficiently and, ultimately, cost-effectively, there exist several organizational impediments such

as power, control, autonomy, workflow, and productivity (Hans et al., 2018, Safi et al., 2018, Takian et al., 2012) that may create frictions in the adoption of e-health innovations. By doing so, we underscore the fact that the adoption of these innovations is not just an operational or a technical decision, rather it is a broader decision, with intangible aspects playing an equally important role. Observing this, we suggest that the organizations adopting these innovations should onboard their human resources department fully to properly plan and execute the implementation as a well-visualized change management process.

Finally, by revealing that the resistance of the implementing organization may come from administrative challenges such as the skill level of staff, training requirements, additional compensation expectations, etc. (Dubin et al., 2020, Plumb et al., 2017, Taylor et al., 2015), as well as from the clinical features that affect the quality of care (Alrahbi, Khan, Gupta, Modgil, & Chiappetta Jabbour, 2022, Zwaanswijk et al., 2011), we provide action-oriented inputs to the manufacturers and marketers. To elaborate, we suggest that ease of use should be emphasized continually, and all innovations should be accompanied by proper demo support and self-help videos that can be referred to as and when required. To address the quality-of-care concerns, the manufacturers and marketers of e-health innovations should have a systematic approach to capture reviews, feedback, and testimonials of different user groups to serve two specific purposes: (i) provide inputs for subsequent product improvements, and (ii) reassure potential users about the effectiveness of the concerned innovation.

Our study offers a comprehensive, first-of-its-kind review of the state-of-the-art literature on resistance to e-health innovations, yet it has certain limitations that need to be acknowledged. First, although we followed recent studies (e.g., Christofi et al., 2021, Vrontis et al., 2022) to execute a robust and systematic search and review of congruent studies, there might be certain keywords or studies that we have missed due to our inclusion and exclusion criteria. Second, we limited our search to only two digital databases, Scopus and the Web of Science, which could have led us to miss some relevant studies indexed in other databases. However, the two databases are known for their extensive indexing, assuring us that there is unlikely to be any grave omission. Third, apart from the methodological limitations, there is also a possibility of human error in shortlisting and/or synthesizing the reviewed studies, which could have affected the reported analysis. However, the author team tried its best to limit such errors by undertaking independent coding at each stage and comparing the output.

Future researchers can take our review study forward by (a) searching additional databases to include studies that may have been inadvertently excluded by us, (b) conducting a meta-analysis of the studies to provide deeper insights into the underlying literature, and (c) undertaking a bibliometric analysis of the literature in the area to generate a detailed research profile to help future researchers.

7. Finance and Fundraising

In addressing the pervasive challenge of consumer resistance to e-health innovations, our comprehensive business plan leverages insights derived from a systematic literature review (SLR). This research delves into the perspectives of patients, healthcare professionals, and various stakeholders, identifying micro, meso, and macro barriers to adoption. Recognizing the evolving landscape of healthcare digitization, our plan underscores the need for nuanced research on user behavior to drive successful implementation.

To facilitate the execution of our research and intervention initiatives, our finance and fundraising strategy is strategically centered around engaging angel investors and securing series funding. These avenues not only offer financial support but also align with our mission to overcome resistance systematically.

Engaging angel investors provides not just capital but valuable expertise and mentorship. These individuals, often experienced entrepreneurs or industry experts, bring insights that extend beyond financial support. Their involvement is crucial in guiding our research, ensuring its relevance, and enhancing the scalability and impact of our interventions. The funds obtained from angel investors will primarily be allocated to:

Establishing and maintaining a state-of-the-art research infrastructure, including advanced technologies and tools required for in-depth analysis and data interpretation. Facilitating collaborations with leading experts in healthcare, technology, and consumer behavior to enrich our research methodologies and broaden the scope of our findings.

Attracting skilled professionals, researchers, and data analysts to strengthen our team and enhance the depth of our research capabilities. Securing series funding represents a crucial phase in our financial strategy, allowing us to scale our operations and interventions. The funds from series funding will be strategically allocated to conducting comprehensive studies that address resistance across various stakeholders, including patients, healthcare professionals, policymakers, and community leaders.

It will also be used to implement targeted intervention programs based on research findings, aimed at mitigating resistance and fostering the adoption of e-health innovations and launching impactful public awareness campaigns to educate stakeholders about the benefits of e-health innovations and dispel myths contributing to resistance.

Through a strategic combination of angel investments and series funding, our finance and fundraising plan aims to not only support our research endeavors but also drive tangible interventions that contribute to the widespread adoption of e-health innovations. The iterative nature of our research and intervention process ensures a dynamic approach, adapting to emerging challenges and opportunities in the ever-evolving healthcare ecosystem.

8. Conclusion

Our study rests on the premise that despite being widely acknowledged for supporting efficient and effective delivery of medical services, e-health innovations have not become an integral part of the healthcare system. Even in most advanced countries, a variety of e-health initiatives have received lukewarm response. Such disengagement and lack of acceptance is depriving the healthcare system from delivering cost-effective and inclusive medical care. Given the criticality of the issue, the factors contributing to limited adoption of e-health innovations cannot be ignored. Taking cognizance of need, our study examines the reasons behind low diffusion of e-health innovations. We contribute to the literature by curating and critically synthesizing the barriers that comprise resistance of three key stakeholder groups – patients, doctors and clinical staff, and hospital management towards e-health innovations, and suggest potential research questions that need to be addressed.

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Navigating Business Cycles: Relationship Marketing in Good and Bad Times

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1. Abstract

Business cycles (BCs) can alter the conditions for long-term business-to-business (B2B) relationships. Based on relationship marketing (RM) and interorganizational learning theories, the authors propose a model that explains relationship configurations that reveal opportunities under economic uncertainty. In the Pilot Study, the authors identify key mechanisms of RM process (communication openness, technical involvement, and customer value anticipation) and performance outcomes (price, cost-to-serve, and expectation of relationship continuity) from the supplier's view. In Study 1, the proposed model is tested with a sample of large size, market leader firms in times of economic crisis (T1). In Study 2, conducting a multi-group analysis, the same sample is used to test the model in times of recovery/expansion (T2). The findings offer directions for suppliers on how to leverage B2B relationships through a BC. Particularly, the authors indicate that supplier's performance is influenced differently by RM mechanisms during times of economic crisis versus times of recovery/expansion.

2. Introduction

The positive effects and dynamics of relationship marketing (RM) have been well established in the literature (e.g., Palmatier et al., 2006, Zhang et al., 2016), especially for business-to-business (B2B) settings (Mora Cortez & Johnston, 2017). However, the influence of increasing competition, customer complexity, and market turbulence is creating a latent hazard for the sustainability of established buyer–seller relationships. Nordin and Ravald (2016) assert that a long-term relationship can suffer from a change in customer needs or when the supplier's portfolio and strategy are modified. These changes are commonly triggered by fluctuations in the business environment (Dekimpe & Deleersnyder, 2018). One key contextual factor is a change in the economic trajectory. The contraction facet of a business cycle (BC) is characterized by a downturn in gross domestic product (GDP) and local currency depreciation. For example, Thailand experienced a drop in GDP growth from 5.5% to −10% during the Asian crisis with a fall of the Thai baht from approximately 25 baht per 1 USD to>50 baht (Grewal & Tansuhaj, 2001). In this scenario, high levels of uncertainty and related threats endanger the viability of an organization (Ellram & Krause, 2014). Therefore, companies strive to manage and survive economic fluctuations. Crises emerge from a bank run and/or correction in the exchange rate of a country. The latter can be identified more objectively (Dutt & Padmanabhan, 2011) and, thus, is the focus of this research.

Extant literature on RM suggests that interorganizational learning is an important way for firms to access markets, develop marketing responses, and leverage process capabilities of partners (e.g., Im & Rai, 2008, Mora Cortez and Hidalgo, 2022, Yang et al., 2014). In this sense, Williamson (1991) recognizes that bilateral relationships can be established to minimize potential governance problems during the exchange. The advantage of organizations over markets (i.e., nominal price dependency) and hierarchy (i.e., authoritative control) lies in leveraging the human ability to take initiative, cooperate, and learn (Ghoshal and Moran, 1996, Im & Rai, 2008). Therefore, if organizations fail to create the relationship context necessary to build new knowledge, economic failure is anticipated (Holmqvist, 2003, Ghoshal and Moran, 1996). Particularly, macro-economic uncertainty introduces relevant contingencies to the exchange, creating an adaptation problem (Heide, 1994).

Prior research on transformational relationship events has generally focused on ad hoc strategies (e.g., Salo, Tähtinen, & Ulkuniemi, 2009) and the

attitudes and behaviors of practitioners (e.g., Nordin & Ravald, 2016), neglecting the potential impact of environmental turbulence. The repercussions of economic swings have been widely investigated from different perspectives, including those of market orientation (Brenčič, Pfajfar, & Raskovik, 2012), psychology (Halpern, 1989), social policy (Weick, 1988), sales force activities (Lee & Cadogan, 2009), strategic capabilities (Grewal & Tansuhaj, 2001), technological structure (Pauchant & Douville, 1994), and trust and privacy on the Internet (Luo, 2002). In an effort to keep developing the understanding of buyer–seller relationships, Nordin and Ravald (2016, p. 2496) called for research regarding the need to explore relationship dynamics in business contexts characterized by high turbulence following quantitative testing. A BC accounts for high turbulence during economic contraction (Ellram and Krause, 2014, Jüttner and Maklan, 2011), providing an appropriate setting for this research.

Industrial suppliers, such as Grainger, successfully navigated customer relationships during the subprime mortgage crisis and readapted when the economy expanded again, making clear that firms adjust their behavior during a BC (Dixon & Adamson, 2012). What have they done? Buyers and sellers, via social networks, foster communication, involvement, and value anticipation to adjust the direction of a relationship. Previous research on RM has focused on general strategies for managing relationship performance, such as identifying learning processes to improve absorptive capacity of firms (Lichtenthaler, 2009), knowledge sharing ambidexterity (Im & Rai, 2008), conflict-coordination learning based on positive attitudes and avoidance behaviors (Chang & Gotcher, 2010), accounting for strength-of-ties by relational embeddedness and knowledge redundancy (Rindfleisch & Moorman, 2001), or interactive learning involving experience sharing and shared interpretation among individuals of different organizations (Yang et al., 2014). However, none of these valuable studies has explained how a firm should adapt relationship mechanisms during a BC.

A review of the BC marketing literature indicates the need for research in a B2B setting, extending the study of economic fluctuations beyond the often-used U.S. context (see Dekimpe & Deleersnyder, 2018). Emerging economies are notorious for a substantial share and a critical role of interorganizational relationships in business organization (Khana & Palepu, 2010). For a substantial share of emerging economies, commodities dominate gross domestic products (GDP) that are notorious for cyclical behavior (Drechsel & Tenreyo, 2018).

To the best of our knowledge, there is no previous work that integrates a BC, an industrial setting, and an emerging economy. We add to this body of research by studying the impact of RM process on determining the specific contribution of long-life customers in emerging economies during periods of contraction and expansion. We investigate these phenomena in the context of the recent fall of commodities. In brief, this paper will address this research gap and contribute a framework that answers: (1) How is RM process linked to firm performance during a BC (from the supplier's perspective)? and (2) What are the different mechanisms related to increased firm performance during both times of crisis (contraction) and recovery (expansion)?

We adopt RM and interorganizational learning theories to identify relationship tenets that help suppliers find the way to sustain or increase performance from their B2B long-life customers during economic swings. We contribute to the RM literature and BC literature. First, we identify the key relationship process mechanisms explaining the divergence between managing B2B markets in times of economic crisis and recovery: (A) communication openness, (B) technical involvement, and (C) customer value anticipation, which have direct and indirect effects on the supplier's performance. Second, we test the difference in the modeled relationship mechanisms, allowing the identification of clear strategies to manage a BC. This is consistent with calls to make the recommendations in BC studies more actionable and concrete (e.g., Dekimpe & Deleersnyder, 2018). Finally, unlike most extant work in the RM and BC domains that has examined performance as an aggregative measure (e.g., Grewal & Tansuhaj, 2001) or through price fluctuations (e.g., Gordon, Goldfarb, & Li, 2013) at the firm or category level (see Dekimpe & Deleersnyder, 2018, p. 33), we

consider three outcome variables: (1) selling price, (2) cost-to-serve, and (3) expectation of relationship continuity, at the customer level. The recent coronavirus situation and Ukraine conflict are calling for more research in crisis settings (e.g., Mora Cortez & Johnston, 2020), positioning this study as timely and needed.

3. Marketing Analysis

3.1 Business cycle (BC) and relationship marketing (RM)

A BC involves a period of expansion in many economic activities, followed by a period of general recession/contraction. The critical facet of a BC is the contraction (also referred to as crisis under a more specific definition). According to Grewal and Tansuhaj (2001, p. 68), a crisis represents "a low probability, high impact situation that is perceived by critical stakeholders to threaten the viability of the organization." Economic crises are indicated through price volatility that forces people and organizations to coordinate economic systems through the use of endogenous and exogenous information (Dutt & Padnamabhan, 2011; Brenčič et al., 2012). Crises represent a form of volatile, discontinuous change that raises economic uncertainty (Faulkner, Feduzi, & Runde, 2017). Economic actors perceive uncertainty as threats and/or opportunities (Gilbert, 2006). Linguistically, the term weiji (crisis in Mandarin) has two meanings, danger and opportunity (Lee, Beamish, Lee, & Park, 2009). Therefore, the hostile environment provided by economic crises not only has a downside, but also can offer a firm an opening for growth. Indeed, Austrian business cycle theory holds that price movements indicate dis-equilibria and signal the need for adjustment of business organization (Richardson, 1990). In short, an economic crisis holds a potential scenario of very limited firm growth driving industry towards decline. At the same time, price-swings signal the need to adjust business organization. Thus, crises offer opportunities for firms to learn, adjust and grow faster than others, and such top growing firms are crucial to the recovery of the economy (Peric & Vitezic, 2016).

Mainstream economic theory, while relatively effective to characterize equilibrium situations, tends to be less informative about the dynamics associated with infrequent events associated with uncertainty, such as economic crises (Faulkner, Feduzi, & Runde, 2017). Also, financial markets are particularly poor at identifying a crisis coming (Pattillo & Berg, 2000). Against this background, economic approaches based on uncertainty highlight the contribution of interorganizational networks for adjusting economic organization in dis-equilibrium and foster learning processes (Araujo and Easton, 2012, Frazier et al., 2009). Thus, long-term relationships between customers and suppliers, due to interaction and learning, may be seen as a way out of critical situations and crises (Brenčič, Pfajfar, & Raskovik, 2012). The literature suggests taking refuge in long-term planning, having a high focus on the customer (e.g., Sherman, 2014).

In the context of buyer–seller relationships, four foundational tenets of RM are mentioned in the marketing literature: (1) business interactions result in economic and/or social outcomes; (2) these outcomes are continuously compared with alternatives to determine the level of engagement in the business relationship; (3) positive outcomes during the exchange increase trust and commitment; and (4) positive business interactions produce relational exchange norms that guide the relationship (e.g., Palmatier, Scheer, Evans, & Arnold, 2008). The outcomes at the dyadic level are critical for a comprehensive understanding of RM. While economic rewards, such as perceived value (e.g., increased value-in-use), are relevant, social rewards, such as affective reactions (e.g., satisfaction) and sharing ethics/morals, are at least equally meaningful (Hütten et al., 2018, Mora Cortez and Johnston, 2020). Additional attitudinal and behavioral elements highlighted in the marketing literature are sense of fairness, negotiated rules, and reciprocal actions (Tangpong, Li, & Hung, 2016). Several relational elements, such as trust (Doney & Cannon, 1997), commitment (Morgan & Hunt, 1994), cooperative norms (Cannon & Perreault Jr., 1999), power (a)symmetry (Narayandas & Rangan, 2004), and relationship stages and dynamics (Zhang et al., 2016), support the thesis of long-term B2B relationships as a quasi-integrated structure for scrutinizing market performance (Im & Rai, 2008). Therefore, interorganizational relationships are fertile ground to explore exchange mechanisms that overrule potential negative circumstances in a BC.

In particular, Hütten et al. (2018) suggest that advancing RM theory requires further understanding of buyer–seller relationships as a dialectical process. This view proposes that firms exist in a diverse world characterized by the desire for domination and control. Thus, conflict is key for defining the nature of dialectical processes, representing the confrontation between two entities that embody opposition as a source of a generative mechanism. The opportunity for enriching extant literature derives from the dialectical tensions. Such tensions are defined as "two co-existing contradictory forces with conflicting goals" (Fang, Chang, & Peng, 2011, p. 774). Tensions are not negative per se, and they are always present (Hütten et al., 2018). The dialectical tensions lead to development and change in relationships. In this vein, a potential positive outcome is generated by the opportunity for buyer and seller to work together coordinately.

Research on the dark sides of relationships (Jap & Anderson, 2007; Villena, Choi, & Revilla, 2021) reveals detrimental characteristics of buyer–seller relationships, such as conflict, opportunism or unethical behavior (Oliveira & Lumineau, 2019.) Inter-organizational research reveals that "such dark-side effects in their early appearance may be useful if businesses are capable of effective learning" (Abosag, Yen, & Barnes, 2016, p. 6). Indeed, a growing body of research reports practices that help managers mitigate dark sides, stimulate learning, and elevate relationship performance (e.g., Fang et al., 2011, Villena et al., 2021).

While dark sides are intrinsic trade-offs of inter-organizational collaboration, a turn in a business cycle creates external economic pressure on a relationship. The dialectical tension (seller desires [thesis] versus buyer desires [antithesis]) directly derives from the context, and so it should be exclusively investigated in a specific setting (Hütten et al., 2018; e.g., economic crisis). In the following section, we focus on the impact of the business cycle on buyer–seller-relationships.

3.2 Business cycle (BC) and interorganizational learning

Related to the dialectical view of buyer–seller relationships, the marketing field acknowledges that inter-firm relationships become critical to firms' success when the firms encounter such external competitive pressures in a turbulent business environment (Tangpong et al., 2016). Imbalanced relationship tensions between organizations can be solved through interorganizational learning. If an economic crisis (environmental uncertainty) is strong enough to generate behavioral uncertainty (i.e., inability to accurately predict the behavior of other actors), both parties may have less commitment to the collaboration and explicitly seek self-interest goals, which ultimately influence the effectiveness and outcomes of the collaboration (Heirati et al., 2016, p. 51).

Firms could simultaneously facilitate knowledge exchange and protect their core proprietary knowledge, diminishing the usefulness of the interaction (Yang et al., 2014). Particularly, key decision-makers in both seller and buyer can develop different attitudes toward the economic crisis and its conflicting consequences. For example, some managers with positive attitudes toward conflict will be open to discussing opposing views with the exchange partner, while managers with negative attitudes will tend to seek harmony and keep differences of opinion from being expressed (Chang & Gotcher, 2010). In addition, the fluctuations in a BC can drive knowledge appropriation hazards, emerging from the self-interest of the exchange partners, to internalize and use the core proprietary knowledge and skills of the other partner beyond the scope of cooperation (Yang et al., 2014). Hence, identifying dyadic learning mechanisms to increase performance during a BC is imperative for firms.

Based on dynamic interorganizational learning theory, a successful process of buyer–seller learning through a BC would result from a balance between joint acting (application/exploitation) and joint experimenting (generation/exploration), which is complex to achieve (Holmqvist, 2003). The danger of misunderstanding the relationship process mechanisms in a BC is that it can serve as catalyzer for escalating tension, which consequently "is motive for punishing non-cooperative behavior, adding further costs, wasting opportunities and it has the potential to cause severe and unrepairable conflict" (Abosag et al., 2016, p. 6). At the same time, crises and uncertainty indicate the need and opportunities for interorganizational learning and

adapting economic production to changing economic conditions. Overall, interorganizational learning is a key theme to explore in BCs, as buyer–seller relationships should be managed in a very particular manner to foster value-based cooperation and adaptation during a threatening context (Tangpong et al., 2016).

Relationship marketing links the key insights of interorganizational research with operational aspects of marketing. As a major implication, marketing organizations need to move the focus from supplier processes and control toward customer-perceived value-in-use and relational processes. Relationship marketing has identified three key processes that foster interorganizational learning (Grönroos, 2004, Grönroos and Voima, 2013): (1) buyer–seller communication that opens opportunity for feedback and learning beyond supplier-driven promotion (Grönroos, 2004, Duncan and Moriarty, 1998); (2) technical involvement, such as customization of products and services, sharing of resources, interorganizational coordination of processes (joint processes help to operationalize collaboration across organizational boundaries and stimulate interorganizational learning [Grant, 1996, Grönroos and Voima, 2013]); and (3) customer value anticipaton: Assuming that economic performance is determined by the value-in-use of resources, suppliers need to establish customer-perceived value as the true north of their marketing activities (Ballantyne & Varey, 2006; McDonald, Kleinaltenkamp, & Wilson, 2016). Explicit policies for anticipating customer-percieved value work as pillars for opportunities for adjusting value creation under uncertainty.

4. Competitive Analysis

We first conducted a two-stage workshop with practitioners in B2B settings to discuss the literature on RM and develop a framework to manage BCs. Hence, the Pilot Study goal is to investigate the main relationship mechanisms that could help differentiate how to manage buyer–seller relationships in times of crisis versus times of recovery. Consensus was reached in regard to the main mechanisms derived from the literature (e.g., Grönroos, 2004). Subsequently, in Study 1 we conducted an empirical assessment of the proposed model with a sample of large size, market leaders in an emerging market during a period of currency-type economic crisis (T1), while in Study 2 we conducted an empirical assessment of the proposed model with the same sample during a period of recovery (T2). The goal for the multi-group comparative analysis is to explore the differences in managing B2B relationships during a BC. This allows practitioners to establish specific strategies to drive firm performance. We summarize the research method in Fig. 1. The selection of an emerging economy (Chile) answers calls for more marketing research in non-developed settings (Burgess & Steenkamp, 2006) and particularly Latin America (Fastoso & Whitelock, 2011).

Chile has been one of the fastest-growing emerging economies over the past decade and has shown an export-driven success that made it a role model for the region, obtaining some recognition in the international business literature (Keegan, 2014). Moreover, it decreased poverty from 26% to 7.9% between 2000 and 2015 (World Bank, 2019). However, due to the abrupt decrease of copper prices, reduction of private investment, and adjustments of government policy, Chile's average GDP growth of 5.33% during the period 2010–2013 dropped to<1.92% GDP growth during the period 2014–2016 (World Bank, 2019), affecting companies' financial performance.

Chilean GDP growth fell continuously from 6.11% in 2011 to 1.19% in 2017 (with the exception of the period 2014–2015, when relatively stable values were reached). The Chilean peso depreciated>30% (above the 20% threshold for claiming an economic crisis; Dutt & Padmanabhan, 2011) to the USD in the period July 2011-May 2017 (SII, 2019), from an exchange rate of 1 USD = 462 CH to 1 USD = 671 CH. The overall context affected particularly industrial production (intrinsically related to mining), showing a pronounced and consistent slowdown until 2017 (Trade Economics, 2019). Accounting for the 19-month period, January 2016-July 2017, industrial production performed poorly with an overall negative result during 13 months of this period, reaching an average downturn of −2% per month (Trade Economics,

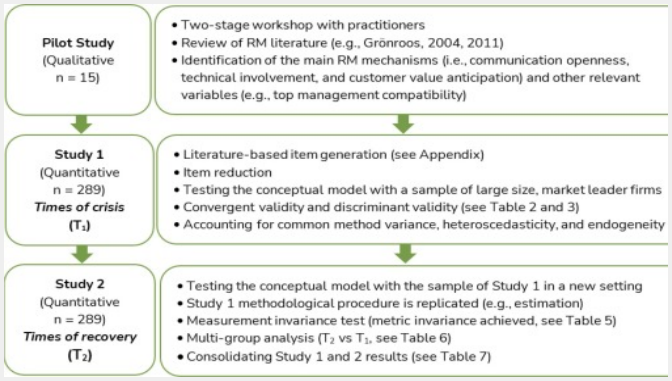

Fig. 1. Overview of the Analysis Method.

2019). Therefore, Chile shows several signs of an economy under currency-type economic crisis during 2017 (T1).

The year 2018 started with a much higher copper price (3.28 USD per pound) in comparison with 2017 (2.48 USD per pound), and sustained an average price superior to 2017, 2016, and 2015 (London Metal Exchange, 2020). As a consequence, the industrial production enjoyed a stronger performance with an average growth of + 3.6% during the January-December 2018 period (Trade Economics, 2019). The Chilean peso also appreciated to a minimum exchange rate of 1 USD = 589 CH during 2018 (SII, 2019). Hence, during 2018 (T2) the Chilean economy shows indications of recovery/expansion. The year 2017 (T1) connected with the year 2018 (T2) accounts for a BC. In summary, Chile offers an example of how an economy can grow out of a crises. We find corresponding insights in our study of interorganizational relationships during the Chilean crisis.

We conducted a two-stage online workshop with 15 experienced B2B managers in cultivating customer relationships to drive their business unit performance. During the first session, we discussed the key processes of relationship marketing (see Grönroos, 2004): (1) communication, (2) interaction, and (3) value. The process approach fosters managerial relevance (Kouamé & Langley, 2018). Participants were informed about the general description of the concepts and reviewed select papers on RM (e.g., Grönroos, 2011, Harmeling et al., 2015). During the second session, the participants in conjunction with the authors discussed the challenges related to a BC and how the readings assimilated practical experiences. The participants, after two rounds of iteration, concluded that (A) the main tenet related to communication is buyer–seller communication openness; (B) the main tenet related to interaction is buyer–seller technical involvement; and (C) the main tenet related to value is customer value anticipation (by the supplier; see Fig. 2).

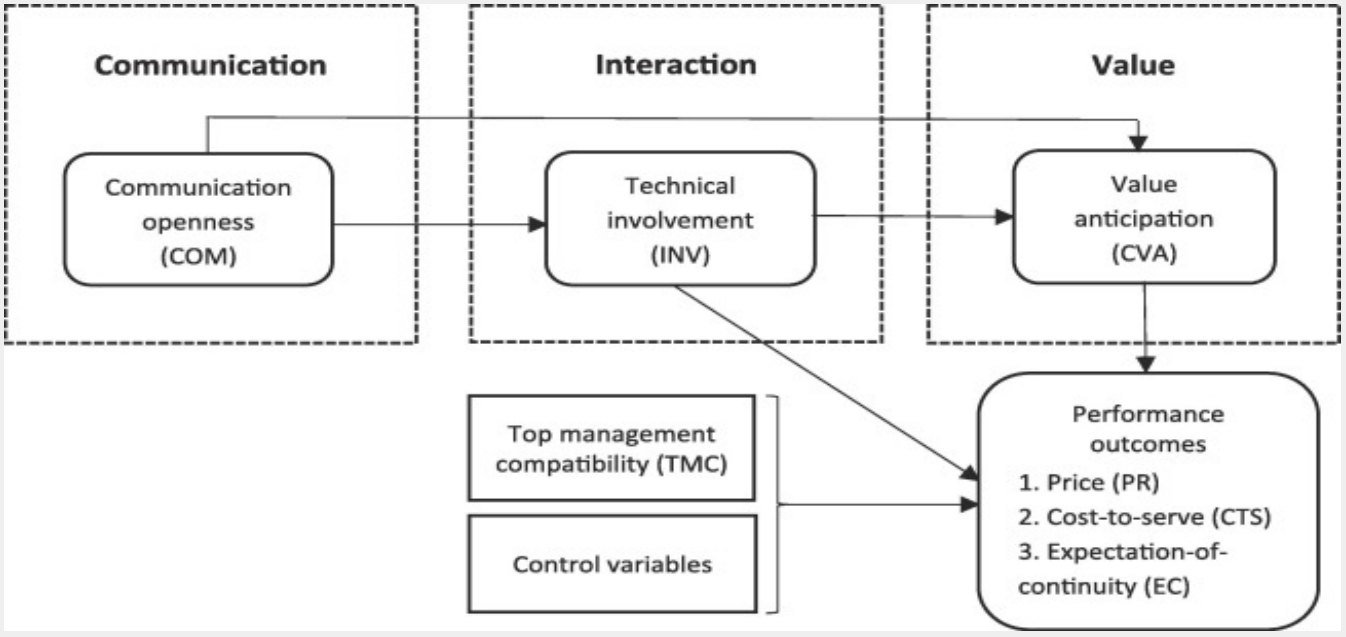

Fig. 2. Conceptual Model.

Buyer-seller communication openness. In general, communication refers to the human activity that

links people together and creates and sustains relationships (Duncan and Moriarty, 1998, Mohr et al., 1996). The buyer–seller communication starts by the parties having the desire to invest time in communicational exchanges. We define communication openness as the extent to which a firm is accessible to establish a dialogue with other parties. Openness is posited to be one way by which relationship gaps can be handled constructively and can lead to buyer–seller investments and willingness to participate in a more entrenched, deeper interaction (Kalafatis, 2000).

Communication implies discrete events through time, not necessarily related. Many academicians emphasize two-way communication through better listening to customers and the idea that communication during the whole customer experience journey can build or destroy important brand relationships (Mohr et al., 1996). The focus of the communication process goes beyond simple persuasive intention; it can involve informing, answering, and listening. Therefore, persuasion has limited impact compared to communication. The notion of persuasion as traditionally used in short-term, transaction marketing is manipulative (Duncan & Moriarty, 1998, p. 2). Companies interested in being more customer-oriented and in developing relationships focus on communication rather than just persuasion. The buyer–seller communication is the platform on which relationships are built (Palmatier et al., 2006). Buyer-seller communication provides data or raw facts about the state of the relationship, making it the most basic level of understanding for a supplier (Mora Cortez & Johnston, 2018). Overall, communication openness involves the willingness to engage in formal and informal sharing of simple (non-sensitive) messages through frequent multiple-channel two-way dyadic interchanges (Jüttner & Maklan, 2011).

Impersonal mass communication must be supplemented, especially in B2B and service categories, by personal customized communication that, by definition, is collaborative (Duncan & Moriarty, 1998, p. 8). Since collaboration is implemented organizationally, relationships across the value chain become more important. Technical involvement refers to an in-depth, specialized buyer–seller interplay, sharing sensitive operational information and establishing cross-organizational collaboration. Involvement implies continuous interaction as a chain of events, being more complex and intertwined than buyer–seller communication events. Jüttner and Maklan (2011) acknowledge that buyer–seller relationships are based on exchange of information and technical integration. In an involvement process, both one- and two-way communication tools are used systematically to strengthen the relationship and increase frequency of interaction. Involvement developed between parties through technical and multi-level interaction (Heirati et al., 2016) is key to understanding business relationships as a social phenomenon.

Technical involvement — as a collaborative idea — is based on the parties' willingness to share sensitive risk and risk event-related information, contributing to uncertainty reduction (Jüttner and Maklan, 2011, Mohr et al., 1996). Collaboration provides the continuity needed for growing shared understanding. As firms collaborate more, buyer–seller involvement strengthens. Through buyer–seller technical involvement, data become meaningful, contextualized and useful (i.e., information; Mora Cortez & Johnston, 2018). Benefiting from inter-firm technical involvement is never deterministic, and the current literature sheds light on factors such as trust, commitment, coordination, and social ties that help firms build effective inter-firm interaction (Heirati et al., 2016, p. 50). Information exchange becomes spontaneous between collaborating parties as they work together over time. During the involvement process between customer and supplier team members, sensitive technical and market information is transferred or acquired (Grant, 1996). Overall, B2B technical involvement implies effort and adaptation within the dyad, especially for the supplier.

Suppliers are not able to offer predetermined value to customers, only the prerequisites for the value (Flint, Blocker, & Boutin Jr., 2011). Thus, to better understand the customers' perspective of value, it is necessary to comprehend and identify what is important to them and what motivates them to use the system or product, i.e., what they value (Yang et al., 2014). Firms should possess the abilities to anticipate customers' potential value (Narver, Slater, & MacLachlan, 2004). Customer value anticipation refers to "a supplier's ability to look ahead at what

specific customers will value from supplier relationships including their product and service offerings and the benefits they create given the monetary and non-monetary sacrifices that must be made to obtain those offering benefits" (Flint et al. 2011, p. 219). From the seller's perspective, it is not only a process for anticipation, but also a process for predicting the outcomes of the marketed offerings.

The value concept is intrinsically related to the desires and needs of the customer during the exchange and usage process. The marketing department may take the lead in this process and predict the outcomes throughout the whole interaction journey with customers. In particular, customers are expecting that firms anticipate their needs and desires, even if "they themselves sometimes cannot" (Zhang, Liang, & Wang., 2016, p. 3726). Customer value anticipation is only possible in situations where the supplier has robust knowledge about the relationship and the industry. This know-how is embedded in the shared understanding of the parties, allowing the anticipation of future needs and behaviors (Flint et al., 2011). Customer value anticipation (CVA) represents knowledge application derived from communication (representing dialogical intent) and involvement (representing collaboration), which, in turn, represent knowledge generation (Grant, 1996).

During the workshop, we also discussed the potential effect of other factors. Particularly, we provided information regarding a meta-analysis, which identified several customer-focused, seller-focused and dyadic antecedents for the effectiveness of RM (see Palmatier et al., 2006). Many participants mentioned that, in times of crisis, the buyer–seller similarity (dyadic antecedent) was important. Similarity is defined as the convergence of culture, values, and goals between organizations (Palmatier et al., 2006). However, several participants indicated that this factor should be operationalized in a more granular manner. It was suggested that buyer–seller top management compatibility (i.e., similarity) is the adequate level of analysis and should be included in the model.

5.3. Performance outcomes

Most participants acknowledged that the key performance outcomes in a BC are: (1) selling price and (2) cost-to-serve. Both measurements are the drivers of customer profitability, an important variable identified in marketing literature (e.g., Palmatier et al., 2008). Surprisingly, the effectiveness of RM efforts posits a poor influence on seller objective performance or does not appeal to the context (Palmatier et al., 2006; 2007). More recent research shows that strong B2B relationships facilitate a simplified buying process and act as a shelter against adverse economic environments (Johnson & Sohi, 2016). However, the paths behind reaching the seller's desired outcomes through a BC remain unexplored (Studies 1 and 2 focus). Many participants are also concerned with how the RM process affects expectation of continuity, which is defined as "customer intention to maintain the relationship in the future, which consequently captures the likelihood of continued purchases from the seller" (Palmatier et al. 2006, p. 139). The RM process was connected to the performance outcomes.

Finally, we conducted three rounds of discussion with the participants via email to consolidate their views on RM mechanisms in times of crisis versus times of recovery. To discriminate the validity of our model, we discussed alternative models, such as conflict-coordination learning (see Chang & Gotcher, 2010), collaborative communication (see Mohr et al., 1996), absorptive capacity (see Lichtenthaler, 2009), commitment-trust theory (see Morgan & Hunt, 1994), and strength-of-ties (see Rindfleisch & Moorman, 2001), that could drive firm performance during a BC. Particularly, we compared the pros and cons of every model, and participants provided experiential arguments supporting the proposed RM process model. We present our conceptual model in Fig. 2.

5. Product Design

We focused on large size, market leader Chilean B2B companies operating mainly with local business customers in different industries (see Table 1 for more details about the sample). These firms were able to be profitable during 2017 and survived the crisis. We collected data during the period January-March 2018 with help from a top-ranked Chilean business school, through the collaboration of companies that continuously participate in the activities held by this entity. We obtained a sample size of 289 complete and usable answers (from a

sample frame of 897 B2B companies [32.21% response rate]), a configuration consistent with previous studies on this topic (e.g., Grewal & Tansuhaj, 2001). As an incentive to participation, we offered to share the results of the research. Before applying the survey instrument, subjects evaluated their industrial context for 2017 (regarding being in an economic crisis) on an 11-point scale with 0 = not at all and 10 = completely; the average result was 7.89. Non-response bias was assessed by a comparison of sample characteristics to known values of the population frame, such as perception of economic performance during the crisis, number of employees, and industries served (Hulland, Baumgartner, & Smith, 2018). The procedure revealed non-significant differences between the sampled and target populations. We required participants to be informed about, engaged with, and interested in day-to-day operations of the focal buyer–seller relationship (Gupta, Kumar, Grewal, & Lilien, 2019). All informants reported being directly responsible for managing customer relationships and their outcomes for at least four years. We instructed each informant to think about a salient long-term relationship (≥5 years) and answer the survey with respect to that customer. To ensure variation in the RM process, managers were randomly asked to focus on a weak, average, or strong relationship. Finally, the questionnaire was translated from the original English version to Spanish and used the back-translation procedure by a professional translator (independent to the authors) to guarantee that meaning was upheld.

We followed Hulland et al.'s (2018) recommendations for marketing survey research. To test our model, we measured the RM mechanisms with items generated from the literature, obtaining a list of 13 items (see Appendix for questionnaire). Following Mohr et al. (1996), communication openness and technical involvement were separated from and to the customer. Based on the Pilot Study, the focus was only from the customer. The items were assessed on an 11-point scale (0 = not at all, 10 = completely). Buyer-seller top management compatibility was measured based on Ellram and Krause (2014). The two economic dependent variables were measured with quasi-objective items (answers were checked by at least two practitioners of each company), where the respondents identified the extremes of the scale with real data, using a 9-point scale. For example, for the question ER2 ("This customer pays more [price per unit] in comparison with the rest of our customers' portfolio in this segment"), the respondent assigned the lowest unitary price as 1 and the highest as 9, and created intermediate scale points by simple rule of three. To measure the expectation of continuity, we used a subjective measure ("Once the market recovers, the likelihood that this customer continues a business relationship with us is very high"). Moreover, to control for other exogenous effects on the dependent variables, we included previous status (2016) of the relationship with the customer (5-point scale with 1 = very weak and 5 = very strong), focus of the offering (dummy variable with 1 = product and 0 = service) of the supplier, focus of the offering (dummy variable with 1 = product and 0 = service) of the customer, industrial sector (using industry dummy variables), market turbulence (using a composite variable based on Jaworski and Kohli [1993]), competitive intensity (using a composite variable based on Jaworski and Kohli [1993]), and number of years of business experience of the supplier's respondent.

Though the use of quasi-objective measures for the dependent variables (DVs) is robust to common method variance (CMV), to minimize its potential bias, we applied five ex ante suggestions from the literature: (1) respondents were assured of the anonymity and confidentiality of the study, (2) the survey design used different endpoint scales for the dependent variables, (3) item ambiguity was checked by a panel of three academic experts (from a large state university in the United States), (4) data collection was conducted at two different time points (T1A, T1B; the DVs were measured at T1B, two months later than T1A), and (5) we randomized the order of the questions per section using Qualtrics (Hulland et al., 2018, Podsakoff et al., 2003).

We conducted confirmatory factor analysis (CFA) to assess psychometric properties and convergent and discriminant validity for the measurement model. We applied statistical reduction procedures to purify the factors, including exploratory factor analysis (EFA), item-total correlation, and reliability analyses (e.g., Cronbach's alpha). We then computed the standardized residual covariances and

modification indices for thorough review of the SEM to analyze potential item deletion (Gerbing & Anderson, 1988). The initial CFA model did not have particularly good fit: chi-square ($\chi 2$) = 305.2, d.f. = 51; comparative fit index (CFI) = 0.80; Tucker-Lewis index (TLI) = 0.74; root mean square error of approximation (RMSEA) = 0.16; and standardized root mean square residual (SRMR) = 0.14.

After the purifying process, the RM process variables resulted in a set of three, three and two items, respectively, and the dependent variables were measured as single-item constructs. Marketing literature asserts that using single-item measures is valid and reliable (e.g., Homburg, Schwemmle, & Kuehnl, 2015). The unidimensionality of the factor model was initially achieved through EFA (maximum likelihood estimation) with oblimin rotation, which allows for intercorrelations among the dimensions. We computed Cronbach's alpha, composite reliabilities (CR), and average variances extracted (AVEs) as reliability measures for each construct. All CRs are > 0.70, all AVEs are > 0.50, and all Cronbach's alphas are > 0.70, indicating that the measures are reliable. We summarize the results of the CFA in Table 2. Overall, each of the factor loadings was significant ($p < 0.01$) and > 0.50 on its respective dimension, suggesting that all indicators captured the constructs they were designed to measure, indicating convergent validity (Gerbing & Anderson, 1988). We successfully established discriminant validity in line with Fornell and Larcker's (1981) criterion, which requires that, for all pairs of factors, the squared estimated correlation is smaller than each factor's AVE. In addition, discriminant validity is established, in that all the correlations are statistically lower than 1 (Anderson & Gerbing, 1988). The fit of the respecified model improved considerably to $\chi 2 = 38.2$, d.f. = 17; CFI = 0.97; TLI = 0.95; RMSEA = 0.09; and SRMR = 0.04. Therefore, the constructs present robust psychometric properties and the CFA model fits the data satisfactorily.

To fully alleviate CMV concerns, per Podsakoff et al. (2003), we included a direct measure of a latent common method factor, allowing items to load on their respective theoretical constructs as well as on a latent CMV factor, and examined the significance of the coefficients with and without this additional factor. The pattern and magnitude of path coefficients did not change significantly and just about 1% of the variance is explained by the CMV factor. These analyses suggest that common method bias is not a major concern.

o test our models, we ran SEMs (in R software), with robust standard errors (MLR estimation) to account for heteroskedasticity. Models' fit yielded acceptable values (CFIs > 0.92, TLIs > 0.90, and SRMR < 0.08; see Web Appendix A), according to Hu and Bentler's (1999) recommendations. We note that RMSEA is higher than the suggested 0.06 threshold, but with a sample size < 250, considering CFI and SRMR, to make a judgment about fit is preferable (Hu & Bentler, 1999). Also, we tested our models using seemingly unrelated regression (SUR; Henningsen & Hamann, 2007) and model implied instrumental variables with two-stage least squares estimator (MIIV-2SLS; Bollen, 2019; see Sargan's tests in Web Appendix B). On one hand, SUR allows estimating all equations simultaneously with a generalized least squares estimator, which takes the covariance structure of the residuals into account, leading to efficient estimates (Henningsen & Hamann, 2007). On the other hand, MIIV-SLS allows correcting for potential endogeneity threats by using observed variables in the model as instrumental variables (Bollen, 2019). The selection of the instruments follows Bollen and Bauer's (2004) algorithm.

For the control variables, non-significant results were found for all the proposed measures at the $\alpha = 0.05$ level, discarding the potential effects coming from the industry classification, type of offering, previous status of the relationship, and experience of the practitioner. The variance explained (on average) for the endogenous constructs are 67.1% for the buyer–seller technical involvement, 60.1% for the customer value anticipation, and 21.2% for the performance outcomes. Based on Westland's (2010) algorithm, a minimum sample size of 137 (considering four latents and 11 items, 0.80 power, 0.30 effect size, and $\alpha = 0.05$) is needed to detect effect.1 Thus, our results are trustworthy from a power perspective.

6.5. Findings

Results are unexpectedly consistent across the three selected methods. We describe the results from

MIIV-2SLS estimation, due to its robustness to missing variables, simultaneity, and reverse causality biases. All item loadings for their respective factors and most Sargan's tests indicate orthogonality of the residuals at the $\alpha = 0.01$ level.

In addition, we investigated buyer's sharing commercial information2 as a moderator for the link between technical involvement and price, and the link between customer value anticipation and price. The rationale is that the pressure from the economic downturn should foster prices being subjected to bargaining. We specified a regression model accounting for heteroskedasticity with technical involvement, customer value anticipation, top management compatibility, control variables, and the two interactions as predictors. This new model yielded an F-statistic = 4.73 with 11 and 207 d.f., significant at the $\alpha = 0.01$ level. The R-squared of the model is 26.44%. The results suggest that the two interaction variables are marginally significant (ps < 0.1; see Web Appendix C). First, the interaction between technical involvement and buyer's sharing commercial information significantly and negatively influences a buyer's selling price during an economic crisis ($\beta = -0.101$, $p = 0.068$). Therefore, large size suppliers with high levels of technical involvement and high levels of buyer's sharing commercial information tend to significantly reduce their selling prices during an economic crisis. It can be inferred that the buyer shares commercial information (e.g., competitor prices) to put pressure on the seller prices, effectively driving price discounts. Second, the interaction between buyer's sharing commercial information and customer value anticipation significantly and positively influences a seller's price during an economic crisis ($\beta = 0.120$, $p = 0.080$). Thus, the higher the level of buyer's sharing commercial information, the more positive is the slope associated with customer value anticipation and selling price. Overall, large suppliers can offset the enhanced negative effect of technical involvement if they can utilize the buyer's sharing commercial information to update and improve their value propositions (e.g., showing value-in-use benefits over rivals' proposals).

6. Marketing Plan

We tested the proposed model with the same sample of B2B firms in the Chilean market, but in a new setting of economic expansion (T2), surveying the same informant of T1. The supplier's managers agreed to participate in the research again, as part of an industrial development program in the host country. The subjects evaluated their industrial context for 2018 (regarding being in an economic recovery) on an 11-point scale with 0 = not at all and 10 = completely; the average result was 8.04. We replicated the Study 1 methodological approach, using MLR and MIIV-2SLS estimations. The MLR and MIIV-2SLS results are similar in both direction and significance (see Web Appendix D). The SEMs yielded satisfactory model fit considering PR, CTS, and EC as DVs (CFI = 0.958, 0.935, 0.963; SRMR = 0.082, 0.083, 0.085, respectively). These fit measures are in line with the established thresholds (Hu & Bentler, 1999). All item loadings were > 0.50, all AVEs were > 0.50, and all construct reliabilities were > 0.70. We found convergent and discriminant validity for all factors, checked with the Gerbing-Anderson (1988) and Fornell-Larcker (1981) criteria, respectively.

Based on the MIIV-2SLS model results (see Sargan's tests in Web Appendix E), interesting differences in the significance and direction of coefficients are identified in comparison with Study 1 findings. For all three models, the path coefficient for the buyer–seller communication openness and customer value anticipation association ($\beta = 0.615$, $p = 0.000$) is significant at the $\alpha = 0.05$ level. Conversely, the path coefficient for the buyer–seller technical involvement and customer value anticipation association ($\beta = 0.148$, $p = 0.163$) is not significant at the $\alpha = 0.05$ level. Hence, during times of economic recovery, firms should generate knowledge to adapt the relationship only via communication (consistent with times of economic crisis). In the model with PR as DV, the path coefficients linked to buyer–seller technical involvement and top management compatibility effect on PR ($\beta = 0.464$; $\beta = 0.436$, respectively) are significant at the $\alpha = 0.05$ level, while the path coefficient associated to customer value anticipation influence on PR is marginally significant ($\beta = 0.221$, $p = 0.092$). To provide further detail (using MLR estimation), we tested the difference between INV → PR coefficient and CVA → PR and TMC → PR coefficients, finding positively significant differences at the $\alpha = 0.10$ level (i.e., βINV > βCVA and βINV > βTMC). In the model with CTS as DV,

only the influence of technical involvement on CTS is significant (β = -0.451, p < 0.05), whereas the coefficients for customer value anticipation and top management compatibility effect on CTS.

(β = -0.183; β = -0.114, respectively) are not significant at the α = 0.05 level.

In the model with EC as DV, all the path coefficients linked to technical involvement, customer value anticipation, and top management compatibility are significant (β = 0.599, p = 0.000; β = 0.390, p = 0.001; β = 0.890, p = 0.000, respectively). To provide further detail (using MLR estimation), we tested the difference between INV → EC coefficient and CVA → EC and TMC → EC coefficients, finding non-significant differences at the α = 0.10 level. To validate that the findings from Studies 1 and 2 are comparable and to what extent, we ran a measurement invariance test. This approach assesses a major potential confound in the data: measures could behave differently in different groups (i.e., T2 vs. T1). Our data support metric invariance (using MLR estimation), which allows a meaningful comparison of slope differences across groups. The fit of the model assuming metric invariance is acceptable and not significantly different from the less constrained configural model (Δχ2PR = 1.950; Δχ2CTS = 3.503; Δχ2EC = 2.935; ps < 0.05).

Invariance	d.f.	CFI	BIC	Δ BIC	Δ χ^2	*p*-value
DV: PR						
Configural	62	0.938	7745			
Metric	67	0.940	7720	−25	1.950	0.856
Scalar	72	0.942	7694	−26	2.012	0.847
DV: CTS						
Configural	62	0.930	7978			
Metric	67	0.931	7954	−24	3.503	0.623
Scalar	72	0.933	7928	−26	1.894	0.863
DV: EC						
Configural	62	0.950	7550			
Metric	67	0.951	7525	−25	2.935	0.710
Scalar	72	0.953	7499	−26	2.042	0.843

Table 1. Measurement Invariance

At the α = 0.10 (two-tailed) *At the α = 0.05 (two-tailed).

In the model with PR as DV, both the INV → PR and TMC → PR coefficients are significantly lower in the crisis scenario (Δβ = 1.138, p < 0.05 and Δβ = 0.221, p < 0.10). The association between CVA and PR remains statistically similar in both times of crisis and times of recovery/expansion (Δβ = -0.301, p > 0.10). In the model with CTS as DV, while the CVA → CTS coefficient is significantly higher in times of recovery/expansion (Δβ = 0.381, p < 0.05), the INV → CTS coefficient is significantly higher in times of crisis (Δβ = -0.756, p < 0.05). In addition, the TMC → CTS association (Δβ = 0.073, p = 0.563) does not differ between the groups at the α = 0.05 level. In the model with EC as DV, both INV → EC and CVA → EC coefficients significantly differ between the groups, with the recovery scenario showing higher influence for INV and CVA on EC (Δβ = 0.815, p = 0.000 and Δβ = 0.309, p = 0.028, respectively) at the α = 0.05 level. Also, the association between TMC and EC does not significantly differ between the groups (Δβ = -0.052, p > 0.10).

Overall, times of economic crisis/contraction provide less RM process opportunities for suppliers to increase customer-level profitability and expectation of relationship continuity. Regarding the nine links to the DVs in each scenario (T2 vs. T1), in the crisis setting only three effects are significantly higher than zero, while in the expansion setting, six effects are significantly higher than zero. Buyer-seller technical involvement is the most controversial RM mechanism in terms of volatility through a BC. During times of crisis, technical involvement has a negative influence on both price and expectation of continuity and a positive influence on reducing the cost-to-serve customers. Probably, both supplier and customer are fully aware of the crisis risks and concentrate their efforts on reducing dyadic costs that could serve as an argument for the supplier to reduce its price. During times of recovery, technical involvement has a positive effect on both price and expectation of continuity and a negative influence on cost-to-serve. A possible explanation is both supplier and customer being able to perceive the growing opportunities, investing in new procedures or developments that can increase the supplier's cost-to-serve, but simultaneously driving a higher, acceptable selling price. The influences of both CVA and TMC effect on the DVs are more stable through a BC, but not entirely rigid. The CVA influence changes in the CTS model from a negative effect to a zero effect, and in the EC model from a zero effect to a positive effect. The TMC influence changes only in the PR model from a zero effect to a positive effect.

Marketing research has yet to focus on the normative guidelines for managing an industrial business through a BC. Based on RM and interorganizational learning theories, the present research identifies and tests a model to account for price, cost-to-serve, and expectation of continuity variations during a BC in an emerging economy. The process approach follows a temporal structure and increases managerial relevance (Kouamé & Langley, 2018). Our findings demonstrate that large size, market leader suppliers can effectively survive and thrive through a BC via distinct RM mechanisms.

Variable	Effect on PR	Effect on CTS	Effect on EC	Overall Higher Order Effect on Supplier and Relationship
Crisis/contraction				
INV	–	+	–	Profitability can be>0, positive impact on CTS should be higher than negative impact on PR. Risk of relationship dissolution is increased
CVA	+	–	0	Profitability can be>0, positive impact on PR should be higher than negative impact on CTS
TMC	0	0	+	Risk of relationship dissolution is decreased
Recovery/expansion				
INV	+	–	+	Profitability can be>0, positive impact on PR should be higher than negative impact on CTS. Risk of relationship dissolution is decreased
CVA	+	0	+	Profitability is likely to be>0, and risk of relationship dissolution is decreased
TMC	+	0	+	Profitability is likely to be>0, and risk of relationship dissolution is decreased

Table 2. Mechanisms for Successful Relationship Management of a Business Cycle (BC).

Our findings have important implications for theory. First, marketing literature still questions how some firms can enhance their performance through a BC and whether B2B relationships can serve as a quasi-integrated structure to cope with such an economic turbulence. Previous research from both practice and academia (e.g., Grewal & Tansuhaj, 2001) has called for research on economic swings, focusing on the downside of a BC in B2B contexts (Dekimpe & Deleersnyder, 2018) and relational arenas (Ellram & Krause, 2014). Interorganizational theories regularly claim the contribution of buyer-sellerships for navigating and learning under economic uncertainty (Araujo and Easton, 2012, Frazier et al., 2009). However, prior research on buyer–seller relationships has neither explored particular relational mechanisms nor their role in mitigating the financial impact of a BC empirically. We extend this research stream by showing that a BC brings profitability opportunities for the B2B supplier by nurturing a system of mechanisms from long-term dyadic exchange, building over the communication → interaction → value RM process (Grönroos, 2004). In this vein, we introduce the main RM mechanisms (communication openness, technical involvement, and customer value anticipation) that can be configured to successfully navigate a BC, providing quantitative testing. In addition, the performance outcomes are measured at the customer level, following prior literature suggestions (e.g., Gupta et al., 2019). Extant research on buyer–seller relationships through a BC, in turn, has been predominantly conceptual and silent on how managing B2B relationships can differ from times of economic contraction to times of economic expansion (Jüttner & Maklan, 2011). Investments in relationships need to consider forward looking measures such as customer lifetime value (Kumar & Reinartz, 2016). However, the ability to learn from a customer through economic crises should be considered in customer valuation approaches.

Second, we contribute to the dark side of B2B relationships' theoretical underpinnings by showing that the inherent tension created in a BC can be managed by RM mechanisms. This aligns with the view of conflict as disagreement between partners that can be resolved as part of ongoing business (e.g., Chang & Gotcher, 2010). The supplier, through unique patterns of communication openness, technical involvement, and customer value anticipation, can transform the tension into effective learning for adapting the relationship during a BC. Thus, the economic fluctuation can be used not only as a source of relationship maintenance but also to dissipate relationship darkness and to offer a more promising relational future as new dyadic knowledge has emerged (Abosag et al., 2016). The RM mechanisms also serve as nodes to extend the dialectical view on buyer–seller relationships (Hütten et al, 2018). Particularly, high levels of buyer–seller technical involvement are not always required to manage tension (supplier desires versus buyer desires), contesting that collaboration in B2B relationships comes without a downside for both times of contraction and expansion (see Table 7). The economic swing is an opportunity to see change as an ongoing possibility to reach better dyadic results, and then the interorganizational learning achieved serves as a win–win solution for both entities — by positively synthesizing the thesis (supplier desires) and antithesis (buyer desires; Hütten et al, 2018). The evidence for the key role of customer value anticipation confirms the emerging research stream that reveals both rationale and evidence for the impact of marketing processes that explicitly target customer-pervieved value-in-use (Ballantyne and Varey, 2006, Grönroos and Voima, 2013, Macdonald et al., 2016).

Third, we contribute to extending BC marketing literature outside the often-used U.S. environment as requested by Dekimpe and Deleersnyder (2018). The investigation of buyer–seller relationships through a BC in an emerging economy (Chile) also answers calls for more marketing research in non-advanced settings (Burgess & Steenkamp, 2006) such as Latin America (Fastoso & Whitelock, 2011). B2B relationships are a source of learning for both supplier and buyer to enhance their understanding of the market's evolving nature (Holmqvist, 2003). Prior research (e.g., Ghoshal and Moran, 1996, Im & Rai, 2008) notes that organizations can advantage other structural knowledge generation sources since challenges to prosperity can be idiosyncratic to the dyad and its business network. This is especially relevant in emerging markets due to the institutional voids that reign in such markets, which make it difficult for marketers to obtain access to useful information

(Pedada, Arunachalam, & Dass, 2020). Overall, this study is consistent with the vision for this century's marketing research to be all about emerging markets (see Sheth, 2011).

7. Finance and Fundraising

Given that the proposed RM mechanisms influence differently the customer level outcomes (i.e., selling price [PR], cost-to-serve [CTS], and expectation of continuity [EC]), companies have to find ways to manage simultaneously (1) communication openness (COM), (2) technical involvement (INV), and (3) customer value anticipation (CVA). This section focuses on the managerial implications derived from our findings through a BC. We suggest a set of RM strategies in the form of a 2x3 matrix, as shown in Fig. 3, for achieving firm goals: (1) increasing PR, (2) reducing CTS, and (3) enhancing EC. We name each of the six quadrants based on our empirical results. For times of crisis, the cells are named: "Value anticipation based on distant communication," "Cost-oriented joint collaboration," and "Dyadic top management consensus." For times of economic expansion, the cells are named: "Generative hard work," "Controlled technical deescalating," and "Integrated optimal balance" (see Fig. 3). Next, we discuss the specific RM strategies to effectively manage each of these six quadrants.

Value anticipation based on distant communication: To increase the PR during an economic crisis, suppliers need to reduce the INV with customers, while being able to enhance CVA. The opportunity to foster CVA has its origin in the supplier's ability to learn about current customers' needs and wants via communication. Hence, the main challenge for a supplier is to establish high levels of communication without simultaneously increasing the technical collaboration with customers. This is difficult, as communication leads to INV. However, communication media such as email and telephone allow a more distant and controlled conversation (e.g., Hutt & Speh, 2016) and can help suppliers to purposively avoid deeper interaction (from a technical perspective).

Cost-oriented joint collaboration: To reduce the CTS during an economic crisis, suppliers are recommended to establish a strong INV with customers, while keeping ideas associated with customer value for future times. The former can be explained by both supplier and customer being concerned about the operational risks and concentrating the technical work on cost-reducing opportunities, generating savings for both actors. The latter can be explained by the supplier being potentially forced to incur customer-specific technical investments (i.e., resources) without the possibility of transferring or amortizing such additional efforts, increasing supplier's CTS.

Dyadic top management consensus: To enhance the EC during an economic crisis, suppliers should be able to exploit TMC with customers, nudging top managers to reach consensus on how to face the economic crisis together. The crisis serves to focus the dyad on reciprocal actions to overcome the financial threats (Tangpong et al., 2016). Also, suppliers are advised to diminish INV with customers. A deeper, technical collaboration in such a setting can result in additional conflicts that may further erode the B2B relationship.

Generative hard work: To increase the PR during times of economic recovery, suppliers can leverage their ability to be technically involved with customers, to have compatible top managers with their counterparts, and to be able to anticipate customer value altogether. However, the most influential factor is the INV. Hence, suppliers should primarily work on collaborating (e.g., developing a new product/service, integrating manufacturing, optimizing engineering processes). Exploiting TMC and CVA should simply complement the advancement through buyer–seller INV.

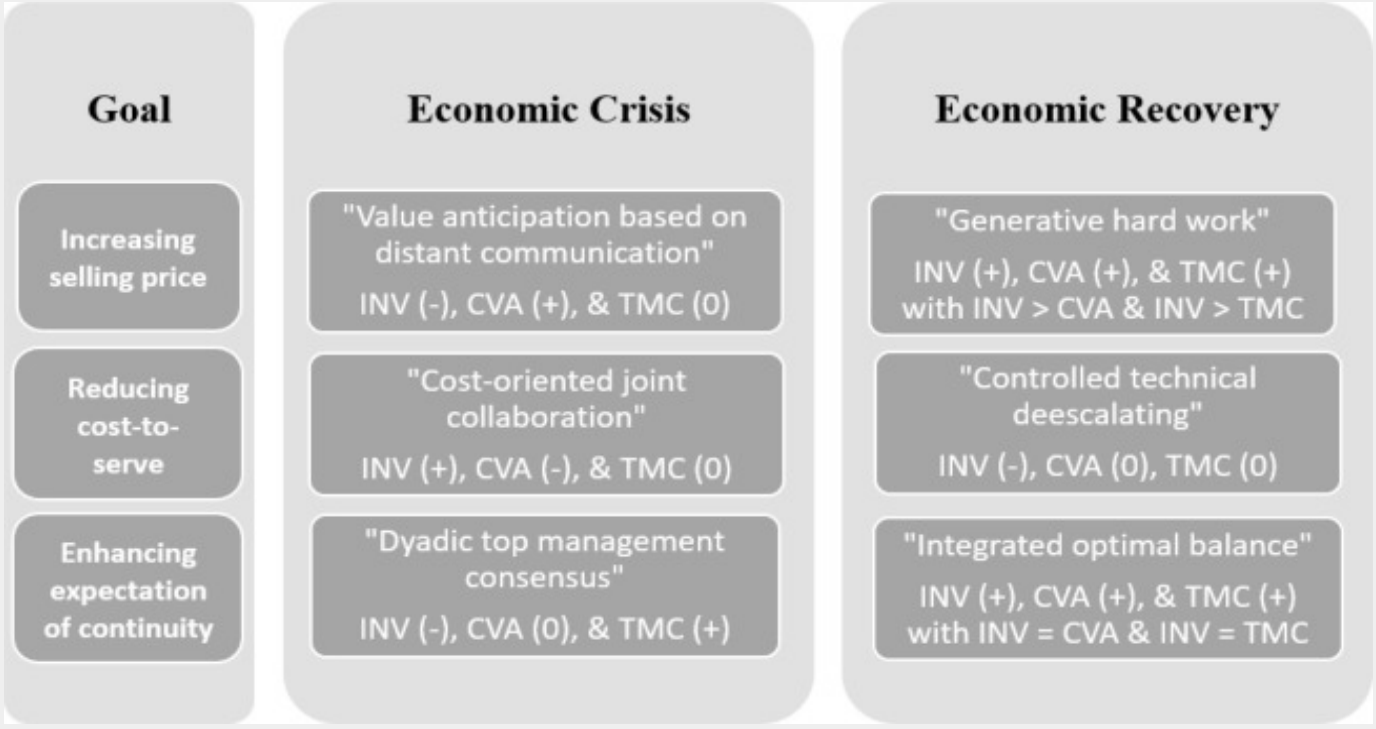

Fig. 3. Relationship Marketing (RM) Strategies Matrix. *PR: Selling Price; CTS: cost to service; Expectation of Continuity: EC; communication openness: COM; technical involvement: INV; customer value anticipation: CVA.

8. Conclusion

Our study's limitations suggest opportunities for future research. First, our data portray RM mechanisms that have not been examined together. However, our longitudinal, comparative approach (i.e., T2 vs T1) considers a period of consistent deteriorating of an economy measured at the worst moment of the contraction stage (2017) and the first period of economic expansion (2018). This pattern may introduce uniqueness into the firms' behaviors and how they manage buyer–seller relationships. Hence, future studies could examine a longer period of time or a different pattern in the BC (e.g., a long period of expansion and the subsequent first period characterized as economic crisis).

Second, we collected RM mechanisms data from key individual managers who are qualified due to their direct participation in administering long-term buyer–seller relationships (for at least four years). Nevertheless, relying on single informants raises common method concerns. Beyond the several actions deployed to prevent inferential biases, future studies could gather data from multiple functions, accounting for the whole selling team. This would create the chance to triangulate different perspectives to relationship management and performance during a BC. Also, future research might gather data from buyers to redefine the unit of analysis at the dyadic level and, consequently, increase the reliability.

Third, we focused on a process approach to RM (e.g., Grönroos, 2004) and tested the environmental effect (i.e., economic fluctuation in a BC) on the whole model. A process approach facilitates providing rich managerial understanding, which is consistent with prior research calling for BC marketing studies being more practice-oriented (e.g., Dekimpe & Deleersnyder, 2018). However, the three RM mechanisms building the path to supplier's enhanced performance can be moderated by other dyadic, supplier, or customer level variables. While we control for endogeneity (e.g., due to missing variables) using MIIV-2SLS estimation and our results are consistent across models, other influential variables (if data on them are available) could be added to the model as moderators of the COM → INV, COM → CVA, and INV → CVA paths. In addition, contextual variables (e.g., market turbulence, competitive intensity) might be used as moderators of the INV → PERFORMANCE and CVA → PERFORMANCE paths3.

Fourth, the nascent theory we developed from our results is confined to a particular phenomenon (the

fall of commodities) and place (large size, market leader Chilean-based firms). While prior marketing research on BC calls for more studies outside the U.S. setting (e.g., Dekimpe & Deleersnyder, 2018), additional efforts should be conducted to generate a comprehensive set of relationship strategies to manage different types of crisis and their recovery. For example, the current coronavirus situation, due to social distancing, can influence differently the configuration of the RM mechanisms to enhance supplier's performance. In addition, other settings commonly neglected in marketing research, such as Southeastern Asia, Africa, and Central America, can adequately serve to elaborate a cross-national research design that allows for comparisons across different institutional systems and population sizes. Moreover, all the suppliers in this study survived the crisis period. Hence, further research can replicate our study with a sample of small size firms, which have been identified to be more susceptible to a BC (Peric & Vitezic, 2016).

Fifth, RM holds an inter-organizational process perspective building on engagement of both suppliers and customers. A key characteristic of relationship marketing approaches is to reside on explicit and direct customer involvement. In communication and technical operations, relationship marketing processes involve sharing or even delegating control to the customer level. For that reason, the current study prioritized on measuring critical elements of communication on the customer-level, in particular the communication openness and the technical interaction from customers. In that regard, one of the key managerial implications is to prioritize the most promising relationships, one of the most fundamental and recurrent findings in customer relationship research (Kumar & Reinartz, 2016). One implicit implication of this study is to consider the knowledge and learning potential in the valuation and respective prioritization of customer relationships. Still, companies have discretion on how they engage with their customer base. This echoes a growing body of research that shows the critical role of understanding the customer value creation context or "value-in-use" as the true-north for the performance of customer relationships (Ballantyne and Varey, 2006, Grönroos and Voima, 2013, Macdonald et al., 2016). Ultimately, it is those insights beyond the market-signals that offer clues for the adaption of value creation and pathways out of economic downturns. We hope our study proves useful for managers and nudges academics to continue RM-based research in the BC domain.

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The Impact of GHRM Practices on Corporate Economic Performance: A Plan for the Interplay with GSCM and Environmental Performance

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1. Abstract

This meta-analysis of 138 effect sizes from 75 studies examines the effect of green human resource management (GHRM) practices on organizations' economic performance (ECP). The study also considers the mediating role of environmental performance (EP) and green supply chain management (GSCM) in the relationship between GHRM and ECP, including contextual and methodological moderators.

The results demonstrate that GHRM is positively related to ECP both directly and indirectly through EP and GSCM. Some contextual (industry type, individualism, masculinity, and long-term orientation dimensions of national culture) and methodological factors (the number of GHRM dimensions) moderate the relationships surrounding GHRM.

Our findings underline the relevance of the effective alignment between GHRM practices and the distinct role of different GHRM practices in promoting ECP. We also highlight that national culture issues could shape GHRM effectiveness and the importance of the effective implementation of GHRM practices for understanding the role of contextual and methodological moderators.

2. Introduction

Green human resource management (GHRM) refers to "the human resource management aspects of environmental management" (Renwick et al., 2013, p. 1); it is relevant to "understand relationships between organizational activities that impact the natural environment and the design, evolution, implementation and influence of [human resource management] systems" (Ren, Tang, & Jackson, 2018). GHRM highlights the importance of human resource management (HRM) to addressing environmental threats that organizations face nowadays (Tanova & Bayighomog, 2022), also helping to improve the health of our planet and people's well-being (Renwick, 2018).

In line with strategic HRM studies, an important amount of research on GHRM has shown interest in examining the effect of GHRM practices on performance, in particular firms' environmental performance (EP). The influence of GHRM practices on other environmental outcomes, such as pro-environmental behavior, has also been examined in depth (e.g., Chaudhary, 2020, Kim et al., 2019, Paillé et al., 2014).

Nevertheless, only a limited number of empirical studies have analysed the effects of GHRM on nonenvironmental outcomes, in particular firms' economic performance (ECP). Given that the interest in GHRM started around 15 years ago, the number of empirical studies is still low compared with other management topics, and around 80% of the studies were published after 2016 (Khan & Muktar, 2020).

It is necessary to shed light on the relationship between GHRM and ECP. First, there is a need to integrate results from different studies (Ren et al., 2018). Despite the fact that most studies have confirmed a significant positive relationship between GHRM and ECP, prior research has not found evidence for it when considering particular GHRM practices (Nawangsari & Sutawijaya, 2019). This suggests that the link between GHRM and ECP is complex, requiring further empirical development (Ren et al., 2018). In addition, prior research examining the effect of GHRM on ECP has found

great variability among the effect sizes, ranging from 0.10 (Nawangsari & Sutawijaya, 2019) to 0.78 (Ogbu & Okwurume, 2019). This variability could suggest that contextual or methodological factors are relevant to understanding this relationship and necessary to examine how certain conditions frame the effect of GHRM practices on firms' performance.

Even though some systematic literature reviews and meta-syntheses of the GHRM domain have been published recently (e.g., Khan and Muktar, 2020, Nobari et al., 2018, Paulet et al., 2021, Pham et al., 2020, Yusliza et al., 2019), these reviews mainly are descriptive in nature, without providing an integrative analysis of the magnitude of effects of GHRM practices on ECP. They leave unanswered some questions about the effect of GHRM on ECP.

Second, a better understanding of the relationship between GHRM and ECP also involves shedding light to the underlying mechanisms between both constructs. Prior research (Acquah, Agyabeng-Mensah, & Afum, 2020, Yu et al., 2020, Yusoff et al., 2020) has highlighted the role of GHRM practices in enhancing EP and promoting green supply chain management (GSCM). Improving EP and implementing GSCM practices could help organizations enhance their ECP by saving energy, materials, and water or by reducing wastes within organizations' facilities and along the supply chain (Pereira et al., 2018). However, implementing GHRM practices could involve the investment of a significant amount of financial resources (Carballo-Penela & Castromán-Diz, 2015), which could affect firms' ECP. Along this line, Agyabeng-Mensah et al. (2020) found that the adoption of some GSCM practices negatively affected the ECP of firms. As a consequence, there is a need to examine the mediating role of EP and GSCM in the relationship between GHRM and ECP.

Because large companies usually have more resources for managing environmental issues than smaller ones, business size could be relevant to understanding the relationship between GHRM and ECP (González-Benito & González-Benito, 2006). Considering that environmental pressures from stakeholder groups are related to the importance of businesses' environmental impact, and that this varies according to the type of activity, industry type could also shape the relationship between GHRM and ECP (Saifulina et al., 2021).The HRM literature clearly underlines that employees' perceptions and interpretations of human resource (HR) practices play a relevant role in influencing the effectiveness of such practices (Jiang et al., 2012, Wang et al., 2020), suggesting that national culture could frame employees' perceptions of HRM practices. Hence, it also makes sense to analyse the moderating effect of national culture on the relationship between GHRM and ECP and other outcomes from GHRM.

There is also a need to further refine GHRM measurement and a better understanding of how employees perceive and respond to GHRM (Ren et al., 2020). A consideration of methodological moderators, such as response rate or the number of dimensions used to measure GHRM, could help in understanding how GHRM influences organizations' outcomes.

Survey response rates may influence the quality of collected information, because the number of polarized answers could be overestimated in samples with low response rates (Friend et al., 2020). The number of considered GHRM dimensions could increase or reduce the effects of GHRM given that a higher number of dimensions increases the possibility of synergies among HRM practices (Subramony, 2009).

Drawing on the ability–motivation–opportunity (AMO) model (Appelbaum et al., 2000) and the resource-based view of the firm (Barney, 1991, Wernerfelt, 1984), the primary objective of this study is to develop an integrative model to shed light to the relationship between GHRM practices and firms' ECP through a meta-analytic approach.

We aim to provide a more profound knowledge on the mediating mechanisms between GHRM and ECP, examining the mediating role of EP and GSCM and analysing the role of contextual (company size, industry type, and national culture) and methodological (response rate and the number of dimensions used for measuring GHRM construct) moderators that shape the effect of GHRM practices on ECP, EP, and GSCM. The consideration of conditions under which GHRM influences ECP helps the proposed model provide integrated

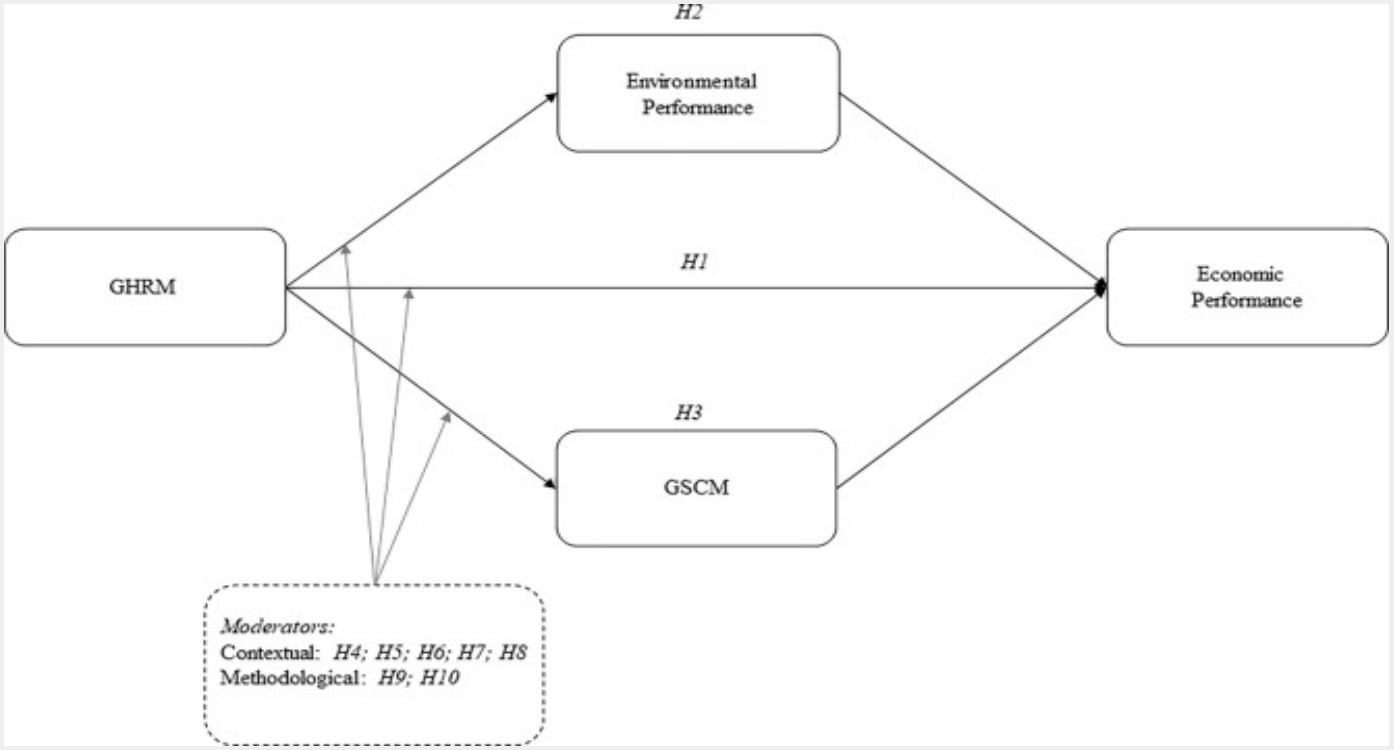

Fig. 1. Proposed model.

knowledge that can be extrapolated across different contexts (Fig. 1).

Following a meta-analytic approach allows for the provision of empirical generalizations regarding the studied relationships (Lim et al., 2022). Meta-analysis provides an integrative framework for research synthesis, which allows for an overall estimate and range of effects, also identifying variability or heterogeneity among the studied results (Imperiale, 1999, Itani et al., 2019). By performing meta-analytic research, this study enables a robust scientific understanding by generalizing key findings in the GHRM domain to understand the relationships between GHRM practices and ECP. To our knowledge, this study is the first meta-analysis to focus on understanding the effects of GHRM.

3. Market Analysis

The analysis of the relationship between GHRM and desired outcomes is carried out from different perspectives (Ren et al., 2018). Assuming that GHRM practices are powerful tools to promote employees' positive behaviors, several scholars have adopted the behavioral perspective of HRM (Jackson et al., 1989, Jackson and Seo, 2010).

The AMO model of HRM (Appelbaum et al., 2000) is often used either explicitly or implicitly by GHRM researchers who adopt a behavioral perspective (Renwick et al., 2013). AMO theory suggests that three elements are needed to ensure performance: (1) the necessary skills (ability), (2) the appropriate motivation (motivation), and (3) an opportunity to perform (participation).

HRM practices can be conceptualized in line with these three elements of the AMO model, distinguishing skill-enhancing HR practices, motivation-enhancing HR practices, and opportunity-enhancing HR practices (Jiang et al., 2012, Lepak et al., 2006). In a similar vein, GHRM researchers have proposed that different GHRM practices (e.g., green recruitment and selection, green training) provide employees with the necessary skills, increase employees' motivation (e.g., green performance management practices, green rewards), and provide the opportunity to participate (e.g., green-involving practices; Ren et al., 2018, Renwick et al., 2013).

Although many GHRM researchers have adopted the behavioral perspective, alternative approaches focusing on employees' competencies within organizations, more than on their behaviors, are also interesting for examining the relationships between GHRM practices and performance outcomes (Ren et

al., 2018). The resource-based view of the firm emphasizes that a competitive advantage can be obtained through the availability and management of valuable, rare, inimitable, and not-substitutable resources (Barney, 1991, Wernerfelt, 1984). HR practices can be used to create and maintain valuable human resources with skills, knowledge, and experience, which drive organizations to a better ECP (Jiang et al., 2012, Pereira and Bamel, 2021, Snell et al., 1996). In line with this, GHRM practices can contribute to firms' performance by providing human resources with green strategic capabilities, which enhance performance by reducing costs, securing exclusive access to resources, or producing in a way that can be maintained indefinitely (Hart & Dowell, 2011).

3.1 Linking GHRM to ECP

Increased concern about protecting the environment has encouraged organizations to adopt environmental management policies, including GHRM practices (Acquah, Agyabeng-Mensah, & Afum, 2020, AlZgool, 2019; Hadjri, Perizade, Zunaidah, & Farla, 2019; Kim et al., 2019, Úbeda-García et al., 2021). A benefit of implementing GHRM practices is that ECP is enhanced (Alharbi, 2020, Bangwal et al., 2017, Malik et al., 2020).

Resource-based view theory supports the idea that the adoption of GHRM practices provides employees with green knowledge and skills that are useful for achieving green strategic capabilities, such as improved reputation and image and cost reductions (Hart & Dowell, 2011), which enhance firms' ECP (Agyabeng-Mensah et al., 2020; Ishaq et al., 2022, Longoni et al., 2018, Wagner, 2013). Furthermore, providing employees with green knowledge may help organizations avoid waste and emissions, reducing the inputs required or removing pollutants from the production process, which is associated with lower costs (Hart & Dowell, 2011).

Several studies support the positive effect of GHRM on ECP. For instance, in a sample of manufacturing firms in the most polluted industrial sectors, Zaid et al. (2020) found that increasing profits and saving costs were the result of spreading GHRM practices. On the basis of these considerations, we hypothesised the following:

(H1): GHRM practices are positively related to ECP.

3.2 GHRM practices could influence ECP through EP

Selecting environmentally committed employees and motivating and encouraging them to be involved in green initiatives could improve firms' EP and, in turn, ECP (Acquah, Agyabeng-Mensah, & Afum, 2020, Ghouri et al., 2020, Masri and Jaaron, 2017, Obeidat et al., 2020, Nawangsari and Sutawijaya, 2019).

The AMO model is useful for understanding the relationship between GHRM and EP (Fongtanakit and Suteerachai, 2019, Gilal et al., 2019, Guerci et al., 2016, Jermsittiparsert et al., 2019, Pham et al., 2020, Yu et al., 2020). The model emphasizes that HRM practices provide employees with the necessary skills that motivate them to participate (Appelbaum et al., 2000). Motivated, capable employees who are supported by their supervisors will successfully fulfil their tasks. Following this reasoning, GHRM practices furnish employees with green abilities that are useful in improving EP (Yong et al., 2022). For example, prior research suggests that green motivation through the implementation of GHRM practices will improve organizational EP (Amjad et al., 2021, Anwar et al., 2020, Elshaer et al., 2021, Jayabalan et al., 2020, Jerónimo et al., 2020, Naz et al., 2021, Ren et al., 2020, Shafaei et al., 2020, Umrani et al., 2020).

Green recruitment and selection practices are intended to provide firms with employees who hold green values, knowledge, and principles (Andjarwati et al., 2019, Nisar et al., 2021, Renwick et al., 2013). Green training and development are focused on questions, such as heightening employee concern about environmental issues, encouraging recycling and waste management, or supporting telecommuting and avoiding long-distance business trips, which could be beneficial to the firm's EP (Arulrajah et al., 2015, Jackson et al., 2011; Ogbu & Okwurume, 2019; Rawashdeh, 2018, Xie and Zhu, 2020). Research also suggests that green performance appraisal and compensation play a vital role in motivating employees to commit to green behaviors at the workplace (Ahmed et al., 2019, Roscoe et al., 2019, Zhang et al., 2019),

helping improve firms' EP (Mousa & Othman, 2020).

Under the umbrella of the resource-based view of the firm, improving companies' EP could create green strategic capabilities that result in better ECP (Hart and Dowell, 2011, Khan et al., 2021). Saving energy, materials, water, and resources through implementing GHRM practices could produce cost reductions that contribute to improving ECP. Enhancing a firm's green image could also result in better ECP (Pereira et al., 2018, Saeed et al., 2018).

This theory has been confirmed in some empirical studies, which suggest the mediating role of EP between GHRM and ECP. For instance, Ghouri et al., 2020, Obeidat et al., 2020 found empirical evidence that encouraging GHRM practices in manufacturing and oil and gas companies had a positive relationship with EP that led to enhanced ECP.

Given such evidence, we hypothesised the following:

(H2): EP positively mediates the relationship between GHRM practices and ECP.

GSCM has become a concern for companies with an objective of maximising their revenue while improving their performance (Acquah, Agyabeng-Mensah, & Afum, 2020, Green et al., 2012, Lee, 2020) in the long term (Jermsittiparsert et al., 2019). GSCM practices include the integration of environmental concerns into the process of commercial activities (Ahmed and Najmi, 2018, Bag et al., 2022, Sahoo and Vijayvargy, 2021) and have a potential to bring environmental and economic benefits (Jiang et al., 2020, Laari et al., 2018, Wongleedee, 2020, Zaid et al., 2019).

According to the AMO model, GHRM practices could provide employees with the necessary green skills, motivating them to participate in environmental initiatives, including GSCM practices. GHRM could play a key role in providing capable and environmentally committed employees interested in applying environmental principles to core supply-chain business processes (Longoni et al., 2018). As a consequence, GHRM could have a positive influence on reducing the barriers to the successful implementation of GSCM practices (Fongtanakit and Suteerachai, 2019, Jabbour and De Sousa Jabbour, 2016, Nejati et al., 2017, Teixeira et al., 2016, Xie and Buavaraporn, 2019). For example, Longoni et al. (2018) found that GHRM practices become a key internal driver of GSCM practices.

Internal and external GSCM practices, such as green purchasing, cooperation with customers and suppliers, and eco-design, could reduce inventory investments and used resources, increase asset recovery, contain costs, and improve reputation (Geng et al., 2017, Laosirihongthong et al., 2013, Saeed et al., 2018). For instance, Zaid et al., (2018) observed that internal GSCM practices are associated with an increase in effectiveness in the application of inputs and assets, which in turn lead to reduced costs, which are essential to improve a firm's ECP.

In line with the resource-based view of the firm, promoting GSCM with GHRM practices could create green strategic capabilities from working with suppliers and customers that are useful for enhancing ECP. Prior research has underlined the mediating role of GSCM in the relationship between GHRM and ECP (Acquah, Agyabeng-Mensah, & Afum, 2020, AlZgool et al., 2021, Longoni et al., 2018, Zaid et al., 2018). These studies noted that ECP is enhanced through GSCM practices implemented by competent and environmentally engaged employees inspired by GHRM practices (Acquah, Agyabeng-Mensah, & Afum, 2020, Zaid et al., 2018). As Agyabeng-Mensah et al. (2020) pointed out, GHRM practices are important to encourage employees to improve the green processes of the firm and to work with suppliers and customers in GSCM practices to optimise gains and, consequently, enhance ECP. Hence, we hypothesised that:

(H3): GSCM practices positively mediate the relationship between GHRM practices and ECP.

In addition to testing the direct and mediating hypotheses, this study also examines the effect of several context-level moderators (company size, industry type, and country culture of the respondents) and methodological moderators

(response rate, number of GHRM dimensions) in the surrounding relationships around GHRM.

4. Competitive Analysis

Large companies are usually more interested than smaller ones in implementing environmental practices. Scholars have pointed out different reasons to explain this, including (1) more resource availability for managing environmental issues, (2) more pressure from stakeholders, and (3) more capability to obtain environmental achievements to their customers (González-Benito & González-Benito, 2006).

Because the HR function plays an instrumental role in helping organizations adapt to new requirements and changes (Subramony, 2009, Wagner, 2013), GHRM practices have a high potential to help companies to manage the environment in a better way (Darvishmotevali & Altinay, 2022). Managers from large companies are likely to promote GHRM by providing HR and environmental managers with financial resources and support for this purpose.

Some manufacturing sectors, such as the oil, chemical, and paper industries, are associated with high environmental risk and poor EP (González-Benito & González-Benito, 2006). According to Heede (2014), nearly two-thirds of the worldwide emissions of methane and carbon dioxide between 1751 and 2010 were released by approximately 90 industrial companies. On the other hand, although service sector companies also affect the environment (Arici and Uysal, 2022, Saifulina et al., 2021), they usually represent less environmental impact and risk.

Growing environmental pressures from stakeholder groups make managers from manufacturing companies particularly sensitive to implementing different environmental management practices, including GHRM practices. organizational support and financial resources could lead manufacturing companies to implement a larger number of GHRM practices and design more effective bundles or systems of GHRM practices than service companies.

Environmental and HR managers from large or industrial firms are in a better position to exert more effort in promoting GHRM. This additional effort could (1) strength reputation improvements and cost reductions associated with GHRM, improving ECP; (2) enhance employees' green skills acquired through GHRM practices, raising EP; and (3) reduce barriers to the successful implementation of GSCM practices.

Taking these considerations into account, we therefore formulated the following hypotheses:

(H4): The positive relationship of GHRM practices with (a) ECP, (b) EP, and (c) GSCM practices is stronger in studies that focused on large companies as opposed to those that focused on small companies.

(H5): The positive relationship of GHRM practices with (a) ECP, (b) EP, and (c) GSCM practices is stronger in studies of manufacturing settings as opposed to those of companies from the service sectors.

Individualism pays attention to individual relationships with other individuals or, in other words, between the individual and the collective. In individualistic societies, individuals are presumed to put their own interests before the interest of the group. On the contrary, in collectivistic societies individuals are supposed to put the group's needs before their own (Hofstede and Hofstede, 1991, Middleton and Jones, 2000). By implementing GHRM practices, firms show that they are interested in reducing the environmental impact of their activities. Environmental concern can be seen as a sign that they care about the planet's health and the lives of future generations. Because in individualistic societies individuals are presumed to prioritise their own interests over the interests of other groups, the dominant country cultural values of managers and employees from individualistic societies are not in line with firms' concern for the environment. Managers would not consider GHRM practices a priority, being reluctant to dedicate time and financial resources to implementing them properly. A lack of interest in and acceptance of GHRM practices by managers and employees makes difficult the successful implementation of GHRM practices, weakening the positive effect of GHRM practices on the expected results:

(H6): The positive relationship of GHRM practices with (a) ECP, (b) EP, and (c) GSCM practices is weaker in individualistic than in collectivistic countries.

Masculine societies are driven by competition, achievement, and success (Hofstede and Bond, 1984, Hofstede and Hofstede, 1991). On the other hand, liking what people do is the main motivation for citizens of feminine societies. Individuals from masculine societies consider that work takes priority over family and leisure. Earnings and achievements are very important to individuals from societies where masculine values are dominant (Hofstede, 2022).

The dominant country cultural values of managers from masculine societies encourage them to perform well. When their responsibilities involve implementing GHRM practices, they will dedicate the resources and effort needed to make them successful. For instance, they would not be reluctant, when asked, to dedicate extra time to supervise the implementation of practices or to provide employees with more information about a practice. By ensuring the correct implementation of GHRM, the positive effect of GHRM practices on the expected results will be stronger. According to these observations the following hypothesis is, therefore, proposed:

(H7): The positive relationship of GHRM practices with (a) ECP, (b) EP, and (c) GSCM practices is stronger in masculine than in feminine societies.

Long-term orientation refers to how societies maintain some links with their own past and deal with the challenges of the present and future. In long-term-oriented, pragmatic cultures, personal adaptability is important, relationships are ordered by status, and an emphasis on persistence is an important quality (Hofstede et al., 2010). In contrast, short-term-oriented, or normative societies, are focused on the present or past, which are considered more important than the long-term future. People in normative societies usually respect traditions, emphasize stability, and are very focused on achieving quick results (Hofstede, 2022). In normative countries, obtaining quick results is a priority for managers responsible for implementing GHRM. They will expect that results from GHRM practices are achieved in the short term. To achieve this purpose, for instance, they could implement those GHRM practices aimed at producing results in the short term, avoiding practices whose results are more visible over a long period of time.

Researchers have mainly considered GHRM outcomes, including EP and ECP, considering a short-term horizon, which is in line with normative societies' short-term values. Taking these considerations into account, the following hypothesis is proposed:

(H8): The positive relationship of GHRM practices with (a) ECP, (b) EP, and (c) GSCM practices is weaker in long-term, pragmatic societies than in short-term, normative societies.

The quality of the information collected in surveys is affected by the survey response rate (de la Rocha, 2015). Low response rates may involve biased data because it is more likely that the sample contains more polarized individuals, with clear negative or positive views regarding the proposed questions (Friend et al., 2020). In samples with low response rates the number of low–low and high–high pairings of answers in the studied relationships could be overestimated. As response rates increase, replies from more moderate respondents could be added to the collected data, resulting in a more diversified sample. Accordingly, the relationships between GHRM and the considered outcomes could be overrated in samples with low response rates because they could miss the middle respondents and thus overestimate the polarized ones (Friend et al., 2020). As response rates increase, the percentage of polarized employees decreases, which will attenuate the relationship between GHRM and its outcomes. Taking these considerations into account, we therefore formulate the following hypothesis:

(H9): The positive relationship of GHRM practices with (a) EDP, (b) EP, and (c) GSCM practices is weaker when the study response rate is high.

When HRM practices are combined in systems that provide employees with proper levels of direction, those practices can support each other, producing synergistic effects greater than those from individual HRM practices (Godard, 2004, Subramony, 2009).

Synergies arise because the accumulation of small complementary effects produces combined effects larger than those expected when these elements operate in isolation (Rock and Palmer, 1990, Subramony, 2009).

Researchers interested in GHRM have used different approaches to measure it. Some researchers (e.g., Zaid et al., 2018) conceptualise GHRM as a second-order multidimensional construct. Under this approach, GHRM dimensions are usually identified with commonly used GHRM practices (e.g., green recruitment and selection, green pay and reward, etc.). Other scholars (e.g., Singh, Del Giudice, Chierici, & Graziano, 2020), treat every practice as a first-order unidimensional construct. In both cases, the number of practices considered in every study significantly varies when GHRM consequences are examined. Although some studies consider only one GHRM practice (Xie & Zhu, 2020), the number is higher in other works (Rehman, Kraus, Shah, Khanin, & Mahto, 2021).

Synergistic effects associated with systems of GHRM practices that affect a particular outcome require multidimensional conceptualisations of the construct. When GHRM is measured using a single or a small number of practices, it is difficult to discern whether cumulative effects from different GHRM practices can produce a net result that exceeds the effect of the sum of effects from single practices. As the number of practices increases, the accumulation of small complementary effects is potentially greater. According to these observations the following hypothesis is, therefore, proposed:

(H10): The positive relationship of GHRM practices with (a) ECP, (b) EP, and (c) GSCM practices becomes stronger as the number of dimensions used for measuring the GHRM construct increases.

We used meta-analytic structural equation models (SEMs) and meta-analytic regressions to test the proposed hypotheses (Itani et al., 2019, Jiang et al., 2012). In doing so, we followed meta-analytic process recommendations that were specified in recent meta-analytical research (Friend et al., 2020, Hunter and Schmidt, 2004, Johnson and Jaramillo, 2017).

To identify studies for meta-analytic testing, we used four inclusion criteria to establish the boundaries of our study. First, we searched the Google Scholar, Web of Science, Scopus, and Business Source Premier databases for published studies. Second, within the articles included in the selected databases, we electronically searched for titles using a number of selected keywords consisting of different variants of common terms (e.g., ‘GHRM’, ‘green HRM’, ‘green human resource management’, ‘green HR practices’, ‘green supply chain management’, ‘GSCM’, ‘supply chain environmental cooperation’, ‘green supply chain management practices’, ‘environmental performance’, ‘green performance’, ‘financial performance’, ‘economic performance’, ‘organizational performance’, ‘firm performance’ or ‘sustainable performance’).

Next, we searched for works on particular GHRM and GSCM practices (e.g., green training, green recruitment, green selection, green purchasing, suppliers’ cooperation, environmental cooperation with customers), following commonly used categorisations (Jabbour and De Sousa Jabbour, 2016, Pham et al., 2020, Renwick et al., 2013) of GHRM and GSCM practices. Forward-looking techniques, such as examining scale development work (e.g., Tang et al., 2018), were also used.

Third, we also consulted the reference lists of prior systematic literature reviews, other theoretical reviews (e.g., Jabbour and De Sousa Jabbour, 2016, Malviya and Kant, 2015, Pham et al., 2020, Sarkis et al., 2011), and meta-analytic reviews (Geng et al., 2017, Horváthová, 2010), on the relevant topics. Finally, to include the most recently published articles, we considered articles available before June 2021. At this stage, our search found 1,985 results Pham et al, (2020).

To ensure that the selected articles are useful for this research, different exclusion criteria were applied. First, duplications and nonscientific articles were removed. Articles in languages different from English were excluded as well. Third, we checked the titles and abstracts of the selected studies to assess the fit with our research objectives, removing those that were not suitable. This reduced our database to 293 articles.

Fourth, studies without correlations and other statistical information necessary to calculate effect sizes were excluded (e.g., theoretical and review articles). Because meta-analytic procedures draw on the analysis of pairs of relationships, studies that did not include at least two of the constructs from the proposed research model were not considered. Studies that had explored performance at the individual level, but at a non-organizational level, were excluded as well. After applying this criterion, our search resulted in 74 articles comprising 75 studies.

The coding sheet and instructions were developed in accordance with Friend et al.'s (2020) recommendations. First, we defined the names and definitions of each construct, considering representative articles, common names for each measure, and examples of items from widely accepted scales (Table 1). Financial performance and ECP refer to the achievement of the firms' economic goals (Jiang et al., 2012, Qi et al., 2014, Salama, 2005, Sarumpaet, 2005). Because researchers use similar or identical scales to measure firms' economic and financial performance in the studied sample of articles, we used the term ECP to refer to economic outcomes usually assessed through market, accounting, value, and cash flow measures (Al-Tuwaijri et al., 2004, Andriana and Anisykurlillah, 2019, King and Lenox, 2001).

Data were manually coded by the first three authors. Following Jiang et al. (2012), when studies included two or more independent samples they were coded separately. The three authors determined the studied relationships, also defining study-specific factors (e.g., response rate, number of GHRM dimensions, or country of respondents). Then they independently coded the same random selection of 36 articles to decide how to code the correlation coefficients, sample sizes, and moderating elements considered in the meta-analysis. After agreeing on coding criteria, they coded the data. Doubts were resolved through discussion among the three coders.

After we applied this process, 74 papers representing 75 independent samples were considered appropriate for this research. They included 27,837 respondents from 29 countries, with an average response rate of 50.73% (SD = 27.60).

To perform meta-analysis, raw correlations (r) were disattenuated (rc) to account for measurement error (Goad & Jaramillo, 2014). Then, we computed the meta-analytic Fisher-Z transformed correlations with a random-effects model using Comprehensive Meta-Analysis Version 3 (CMA v3; Borenstein et al., n.d.).

We computed reliability corrections for informant-reported measures of the constructs to correct for measurement errors. For studies that did not report such reliability figures, we imputed the reliabilities using the weighted mean of the available reliabilities estimated from the other studies (Jiang et al., 2012, Lipsey and Wilson, 2001).

We used a random-effects model to correct the sampling error by weighting the correlation of each study by its sample size (Hunter & Schmidt, 2004). The random-effects model provides more conservative and generalisable results because it accounts for possible heterogeneity in the population effect size (Hedges and Vevea, 1998, Jiang et al., 2012, Overton, 1998). Table 2 shows the average effect sizes (raw correlations and disattenuated meta-analytic correlations) and confidence intervals. In addition, we computed Q statistics to assess homogeneity of the bivariate correlations (Rubera & Kirca, 2012) and I2 statistics to estimate the proportion due to heterogeneity (Higgins & Thompson, 2002). The values of both statistics suggest the presence of a significant level of heterogeneity, which could be due to the presence of moderating variables. Finally, we computed Orwin's (1983) fail-safe N statistics, to address publication bias, by estimating the number of studies reporting a nonsignificant correlation (r = 0) that would be necessary to reduce the meta-analytic correlation to the conventional standard of practical insignificance (r = 0.10; Cohen et al., 2003).

Table 2. Derived Meta-Analytic Correlations.

Relationship		95%CI										
Var.1	Var.2	k^a	n^b	r^c	r_c^d	LB[e]	UB[f]	Q^g	ISQ[h]	N^i	CSR[j]	SR[k]
GHRM	GSCM	14	3,438	0.73*	0.89*	0.66	1.12	587.5*	97.8	119	6	94
GHRM	EP[l]	46	11,094	0.64*	0.75*	0.63	0.86	1525.5*	97.2	290	13	87
GHRM	ECP	15	3,145	0.47*	0.65*	0.45	0.85	431.1*	96.8	69	18	82
GSCM	EP[l]	18	15,069	0.54*	0.69*	0.52	0.86	884.1*	98.1	66	15	85
GSCM	ECP[l]	15	14,083	0.51*	0.61*	0.49	0.72	255.8*	94.5	60	20	80
EP	ECP	30	6,095	0.49*	0.55*	0.41	0.68	779.9*	96.4	108	23	77

Table 1. Derived Meta-Analytic Correlations.

To test the proposed hypotheses, we used meta-analytic structural equation modelling (MASEM) for direct effects (Bergh et al., 2016), following Iacobucci et al.'s (2007) procedures to test mediation hypotheses and meta-analytic regressions for moderating effects (Lipsey & Wilson, 2001).

For MASEM analysis, we used the disattenuated meta-analytic Fisher-Z correlations (obtained from the previous meta-analysis with CMA v3), as shown in the lower left of Table 3. Because the sample sizes for different correlations were not identical (Viswesvaran & Ones, 1995), the harmonic mean of the sample sizes of bivariate correlations as the sample size (n = 5,957) was used as well. The smallest number of effect sizes for the included correlations was k = 14, which widely exceeds the k ≥ 3 criterion used in most causal models in business research and marketing (Grewal et al., 2018). For meta-analytic regressions (weighted least square meta-regressions computed using CMA v3), the effect sizes were treated as the dependent variable and the moderator as the independent variable, using the estimated parameters of these regressions and their significance to assess moderations in a sequential manner (Friend et al., 2020, Lipsey and Wilson, 2001). Hofstede (2022) scores for cultural dimensions were used for defining individualism, long term-orientation, and masculinity dimensions of culture, which are considered quantitative variables, ranging from 0 to100.

Variables	1 GHRM	2 GSCM	3 EP	4 ECP
1 GHRM	1	14 (3,438)	46 (11,094)	15 (3,145)
2 GSCM	0.89	1	18 (15,069)	15 (14,083)
3 EP	0.75	0.69	1	30 (6,095)
4 ECP	0.65	0.61	0.55	1

Table 2. Meta-Analytic Correlations Used to Test SEM.

5. Product Design

The bivariate analyses shown in Table 1 reveal that all meta-analytic correlations are positive and significant. Thus, the strongest meta-analytic correlations are those related to GHRM–GSCM (rc = 0.89, p <.05), GHRM–EP (rc = 0.75, p <.05), GSCM–EP (rc = 0.69, p <.05), GHRM–ECP (rc = 0.65, p <.05), and GSCM–ECP (rc = 0.61, p <.05), all with correlations higher than 0.60. Even the weaker meta-analytic correlation, related to EP–ECP (rc = 0.55, p <.05), is higher than 0.50, which shows a great association among the variables under study.

We used a meta-analytic SEM using the maximum-likelihood method to test the direct relationships between the different constructs at the same time. The proposed meta-analytic SEM model provided the results that are shown in Table 4, which initially suggested a close fit to the data ($\chi 2$ = 55.76, df = 1, p <.001), as well as fit indexes that met the conventional threshold values (Kline, 2015, Vandenberg and Lance, 2000): comparative fit index = 0.99, incremental fit index = 0.99, normed fit index = 0.99, Tucker–Lews Index = 0.98, standardized root-mean-square residual = 0.01).

PATH	Estimate	SE	C.R.	*p*	test
GHRM→ECP	**0.44**	0.02	18.36	0.00	***
GHRM→EP	**0.75**	0.01	86.69	0.00	***
GHRM→GSCM	**0.89**	0.02	148.52	0.00	***
GSCM→ECP	**0.13**	0.02	6.10	0.00	***
EP→ECP	**0.13**	0.03	8.96	0.00	***
MODEL FIT SUMMARY	Chi-square=55.76, *df*=1; *p*<.001 CFI=0.99; IFI=0.99; NFI=0.99; TLI=0.98; SMR=0.01				

Table 3. Direct Effects (Meta-Analytic SEM).

Table 3 also shows results regarding standardized path coefficients that were used to test the direct effects. Regarding the hypotheses proposed in the research model, first, the above results show that GHRM is positively related to ECP (0.44, p <.001), thus supporting H1. In addition, with regard to the rest of the direct effects, the results also show that GHRM is positively related to EP (0.75, p <.001), GHRM is positively related to GSCM (0.89, p <.001), GSCM is positively related to ECP (0.13, p <.001), and, finally, EP is positively related to ECP (0.13, p <.001), so all the direct effects were also significant and positive.

Table 4 shows the standardized path coefficients of direct, indirect, and total effects, to test the mediating hypotheses. We used Sobel's (1982) test to examine the statistical significance of indirect effects (Jiang et al., 2012). The results of mediation tests revealed that GHRM is related to ECP through EP (H2: Sobel test = 8.69, p <.001), with a standardized coefficient of 0.54 for total effect and with an indirect ratio (indirect over total effects) of 18.3% through EP. On the other hand, the results of mediation tests also showed that GHRM affects ECP through GSCM (H3: Sobel test = 6.14, p <.001), with a standardized coefficient of 0.55 for total effect and with an indirect ratio (indirect over total effects) of 20.8% through GSCM.

	Direct effect			Indirect effect		Total effect	
PATH	*c'*	*a*	*b*	*ab*	Sobel test	$(a \times b)+c'$	Ind/Tot
GHRM→EP→ECP	**0.44**	0.75	0.13	**0.10**	8.69^{***}	**0.54**	*18.3%*
GHRM→GSCM→ECP	**0.44**	0.89	0.13	**0.11**	6.14^{***}	**0.55**	*20.8%*

Table 4. Indirect Effects (Mediation Analysis).

Finally, Table 5 shows meta-analytic results that were computed using CMA v3, providing the estimated parameters of these regressions and their significance to test hypotheses for context-level and methodological moderators.

Moderator	PATH	Estimate	SE	Lower	Upper	*p*	test
Firm Size	GHRM→ECP	**0.07**	0.47	-0.86	0.99	0.88	*ns*
Firm Size	GHRM→EP	**-0.15**	0.20	-0.54	0.24	0.46	*ns*
Firm Size	GHRM→GSCM	**-0.22**	0.20	-0.60	0.16	0.26	*ns*
Industry	GHRM→ECP	**0.01**	0.21	-0.40	0.42	0.97	*ns*
Industry	GHRM→EP	**0.20**	0.12	0.07	0.52	0.01	**
Industry	GHRM→GSCM	**0.31**	0.24	-0.17	0.79	0.20	*ns*
INDIV	GHRM→ECP	**0.00**	0.01	-0.01	0.02	0.76	*ns*
INDIV	GHRM→EP	**-0.01**	0.00	-0.02	0.00	0.07	*ns*
INDIV	GHRM→GSCM	**-0.02**	0.01	-0.03	0.00	0.02	*
MASC	GHRM→ECP	**0.01**	0.01	-0.01	0.04	0.42	*ns*
MASC	GHRM→EP	**0.02**	0.01	0.00	0.03	0.02	*
MASC	GHRM→GSCM	**0.02**	0.02	-0.01	0.05	0.16	*ns*
LTO	GHRM→ECP	**-0.01**	0.00	-0.02	-0.01	0.00	***
LTO	GHRM→EP	**-0.01**	0.00	-0.02	-0.01	0.00	***
LTO	GHRM→GSCM	**-0.01**	0.01	-0.02	0.00	0.17	*ns*
Response Rate	GHRM→ECP	**0.00**	0.00	-0.01	0.01	0.93	*ns*
Response Rate	GHRM→EP	**0.00**	0.00	0.00	0.01	0.70	*ns*
Response Rate	GHRM→GSCM	**0.00**	0.00	-0.01	0.01	0.76	*ns*
nGHRM dim	GHRM→ECP	**-0.12**	0.05	-0.21	-0.03	0.01	**
nGHRM dim	GHRM→EP	**0.01**	0.04	-0.06	0.08	0.81	*ns*
nGHRM dim	GHRM→GSCM	**0.09**	0.05	0.00	0.18	0.04	*

Table 5. Moderating Effects (Meta-Analytic Regressions).

On the one hand, for context-level moderating effects, the results show that firm size did not have a significant moderating effect for any of the three paths: GHRM–ECP (H4a: 0.07, p =.88), GHRM–EP (H4b: –0.15, p =.46), and GHRM–GSCM path (H4c: –0.22, p =.26). Second, with regard to industry, we found a significant and positive moderating effect for the GHRM–EP path (H5b: 0.20, p <.01). However, we could not find a significant moderating effect for the GHRM–ECP path (H5a: 0.01, p =.97) or for the GHRM–GSCM path (H5c: 0.31, p =.20).

Third, for individualism, the findings show a significant and negative moderating effect for the GHRM–GSCM path (H6c: –0.02, p <.05), but we could not find a significant moderating effect for the GHRM–ECP path (H6a: –0.00, p =.76) or for the GHRM–EP path (H6b: –0.01, p =.07).

Fourth, for masculinity, we found a significant and positive moderating effect for the GHRM–EP path (H7b: 0.02, p <.05), but we could not find a significant moderating effect for the GHRM–ECP path (H7a: 0.01, p =.42) or the GHRM–GSCM path (H7c: 0.02, p =.16). And fifth, with regard to long-term orientation, we found significant and negative moderating effects for the GHRM–ECP path (H8a: –0.01, p <.001) and for the GHRM–EP path (H8b: –0.01, p <.001), but we could not find a significant moderating effect for the GHRM–GSCM path (H8c: 0.01, p =.17).

For methodological moderating effects, the findings show that the response rate did not have a significant moderating effect for any of the three paths: GHRM–ECP (H9a: 0.00, p =.93), GHRM–EP (H9b: 0.00, p =.70), and GHRM–GSCM (H9c: 0.00, p =.76).

With regard to the number of GHRM dimensions, contrary to what was expected, we found a significant and negative moderating effect for the GHRM–ECP path (H10a: –0.12, p <.01). As was expected, results show a significant and positive moderating effect for the GHRM–GSCM path (H10c: 0.09, p <.05). Nevertheless, we could not find a significant moderating effect for the GHRM–EP path (H10b: 0.01, p =.81).

6. Marketing Plan

This meta-analytic study contributes to GHRM research by exploring the relationship between GHRM practices and businesses' ECP, shedding light on the mediating mechanisms through which GHRM practices influence organizational outcomes. In order to add knowledge of conditions under which GHRM influences ECP, the proposed research model also examined the role of context-level and methodological moderators.

Drawing on the AMO model and the resource-based view of the firm, in this study we proposed and demonstrated that the implementation of GHRM practices increases organizations' ECP. In addition, our findings provide further evidence that the relationship between GHRM and ECP is partially mediated by both EP and GSCM.

Despite the fact that the direct relationship between GHRM and the studied environmental outcomes (EP and GSCM) is very strong, our results underline that the effect size between GHRM and ECP (0.44) is fourfold greater than the indirect effect on ECP through EP (0.10) and GSCM (0.11). This implies that EP and GSCM partially mediate the relationship between GHRM and ECP. This information about the effect size obtained through meta-analytic techniques is one major contribution of this research because the results highlight the relevance of the direct effect of GHRM to nonenvironmental outcomes, such as ECP.

The results also show that context-level (industry type and individualism, masculinity, and long-term orientation dimensions of Hofstede's national culture) and methodological factors (the number of dimensions used for measuring GHRM construct) moderate the relationships occurring around ECP.

The dimensions of national culture are the more relevant of the considered moderators. As expected, the results show that individualism makes the relationship between GHRM and GSCM weaker. A masculinity orientation reinforces the relationship between GHRM and EP. On the other hand, a long-term orientation undermines the relationship between GHRM and (1) ECP and (2) EP. In

addition, increasing the number of dimensions used to measure the GHRM construct reinforces the positive influence of GHRM on GSCM. Industry type moderates the relationship between GHRM and EP, which is stronger in manufacturing settings.

Nevertheless, the negative moderating effect of the number of dimensions of GHRM when considering ECP as the outcome is a surprising finding. Costs associated with the adoption of GHRM practices (e.g., costs of providing green training to organization members, establishing environmental audits or, for instance, rewarding EP) can be relevant when considering the relationship between GHRM and ECP. Although the economic cost of implementing GHRM practices should not affect the relationship between GHRM and environmental outcomes, implementation costs could compensate for synergies associated with a higher number of GHRM practices when considering ECP. In this regard, scholars have pointed out that smaller HRM bundles focused on enhancing particular employees' characteristics could deliver similar benefits than bigger ones, without increasing costs substantially (Subramony, 2009).

The importance of the alignment between the practices used to measure GHRM could also explain this finding and the nonsignificant moderating effect of the number of GHRM dimensions on the relationship between GHRM and EP. Although increasing the number of practices potentially opens the possibility of synergetic effects among them, researchers have underlined that synergies require complementarity among the considered practices (Hoque, 1999, Martín-Alcázar et al., 2005). When the considered practices are not aligned, or when they work in a different way, it is possible that synergies do not arise or that the combined effect of the considered practices is divided (Martín-Alcázar et al., 2005). Although strategic HRM researchers have attempted to classify HRM practices according to their complementarity (e.g., Guest et al., 2004, Lepak et al., 2006), researchers of GHRM have not yet paid much attention to understanding how GHRM practices can be bundled together in an effective way (Jackson, 2022).

The obtained findings also show that firm size and response rate do not moderate any of the proposed relationships. These results could be understood considering that many GHRM studies include a wide range of GHRM practices with different levels of effectiveness on the studied outcomes. Although our findings provide useful empirical generalisations regarding the studied relationships, the moderating roles of firm size and response rate could vary depending on the considered practices. Future research could categorise GHRM practices in regard to their effectiveness in promoting ECP, EP, or GSCM. Along these lines, recent studies have underlined that an understanding of the function of specific GHRM practices in promoting outcomes is still scarce (Fawehinmi et al., 2022, Jackson, 2022), and some practices are more useful than others for achieving certain results (Carballo-Penela et al., 2022). More detailed information on the role of different GHRM practices in promoting ECP, EP, and GSCM could help in understanding the moderating roles of size and response rate.

Another interesting finding is that some moderating effects are significative for only one of the three proposed relationships. The results show that industry type, individualism, and masculinity moderate the relationship between GHRM and the studied environmental constructs (EP and GSCM) but not the relationship between GHRM and ECP. We propose that the effectiveness of the implemented GHRM practices could be relevant to understanding this finding.

Prior research has emphasized that the effective/infective implementation of HRM practices and, in particular, GHRM practices, could have influenced the results. However, scholars have not yet paid attention to how effectively GHRM practices have been implemented (Jackson, 2022). Because dealing with GHRM issues is a new challenge for many companies and employees, it makes sense that some studies include results from practices that were not properly implemented. A mixture of adequately and poorly implemented GHRM practices could indicate that implementation issues affect the relationship between GHRM practices and expected results. Because environmental issues are at the core of GHRM practices, they could produce the expected effect on other environmental constructs, even when the practices are not always properly implemented. Nevertheless, poor implementation could strongly affect the relationship between GHRM and

nonenvironmental outcomes, influencing the moderating effects in the relationship between GHRM and ECP. The magnitude of the environmental problems that manufacturing sectors face could encourage manufacturing firms to improve their EP, which would also explain how industry moderates the relationship between GHRM and EP.

In addition to underlining the fact that contextual moderators are relevant to understanding the relationship between GHRM and environmental outcomes, our findings highlight the role of long-term orientation as a relevant moderator in the relationship between GHRM practices and organizational performance, including both EP and ECP. Because cultural values from long-term-oriented societies place importance on the long-term future, a long-term orientation weakens the positive relationship between GHRM practices and firm performance, which is usually defined as considering a short-term horizon.

Although further research is needed, our findings provide new knowledge on how contextual factors frame the effect of GHRM practices and expected outcomes, suggesting two interesting patterns that are useful to guide HRM professionals from different settings (Jackson, 2022). Although a group of contextual factors could shape the effect of GHRM practices on environmental constructs, other contextual moderators, such as a long-term orientation, are particularly interesting in regard to better understanding the relationship between GHRM practices and performance constructs.

This research offers different theoretical contributions to the GHRM research context. First, we adopted different theoretical perspectives to understand the role of GHRM in promoting ECP. Although many researchers have adopted a behavioral perspective that follows the AMO model to examine GHRM consequences, explaining the complexity of GHRM phenomena requires multilevel theorising (Ren et al., 2018). This research combined the AMO model with the resource-based view theory, thus enriching prior research. The use of different theoretical foundations is particularly interesting for demonstrating that GHRM positively relates to ECP by providing employees with the necessary green skills and motivating them to participate in green initiatives, which is useful to achieve green strategic capabilities that provide different sources of competitive advantage.

Second, using meta-analytic techniques, we proposed and tested a comprehensive mediating model that reveals a direct relationship between GHRM and ECP, also mediated through different mechanisms (EP and GSCM). Although the number of studies about GHRM topics has grown quickly in the past few years, researchers have performed piecemeal cross-sectional analyses in different contexts to examine the effect of a wide number of GHRM practices on different outcomes. There is great variance in the magnitude of obtained effect sizes, and the relationships around GHRM are moderated by diverse boundary conditions. It is necessary to integrate results from prior studies in order to provide empirical evidence that is useful in relation to different contexts.

The meta-analytic nature of this research contributes to the integration of existing empirical research, providing robust empirical generalisations that are not observable in a narrative review regarding the studied relationships (Friend et al., 2021). It provides relevant information on the effect sizes and boundary conditions that have not been included in previous systematic literature reviews on the GHRM topic.

Finally, the findings regarding the moderating effects from this study shed light on existing uncertainties about the impact of cross-study variance, providing methodological and theoretical relevance. Our results show that several context-level and methodological factors moderate the relationships surrounding ECP. In this regard, we suggest the (1) alignment between the practices used for measuring GHRM; (2) role of different GHRM practices to promote ECP, EP, and GSCM; and (3) effective/ineffective implementation of GHRM practices need to be considered if one is to understand the role of contextual and methodological moderators.

The results regarding the number of GHRM dimensions are remarkable methodological contributions given that prior research has not considered this construct when examining the

relationship between GHRM and desired outcomes. Our findings underline that the number of dimensions used to measure GHRM can be relevant to understanding the relationships between GHRM and ECP and GSCM.

7. Finance and Fundraising

From a practical standpoint, the obtained findings should encourage companies to implement GHRM practices. Prior research (e.g., Carballo-Penela & Castromán-Diz, 2015) has underlined that not all managers and organizations have made the same effort to deal with organizations' environmental issues and, in particular, to implement GHRM practices. Although several studies (e.g., Fraj-Andrés et al., 2012, Zhang et al., 1997) have pointed out that firms' environmental strategies have different benefits for organizations (saving energy, materials and water, avoiding environmental sanctions, etc.), addressing environmental issues can involve a significant amount of financial resources (Berry & Rondinelli, 1998), which could affect organizations' ECP.

Our meta-analytic results underline the relevance of GHRM to improve firms' ECP, showing managers that investing in GHRM, in addition to contributing to a better EP, could improve their firms' economic results by providing new sources of competitive advantage. Such competitive advantages could prove most prominent in markets where traditional sources of competitive advantage tend to quickly disappear.

In particular, we depicted the relationship between GHRM and ECP, quantifying the direct effect and the mediating role of EP and GSCM. Although this study indicates that GHRM leads to ECP through two mediating processes, our findings highlight the relevance of the direct effect size.

The results of this research shed light on other benefits associated with investing in GHRM in addition to the economic ones. The results show that implementing GHRM practices clearly enhances both GSCM and EP. These findings could encourage managers to use GHRM to bring environmental issues into the upstream and downstream supply chains. In addition, prior literature has pointed out different organizational practices intended to improve firms' EP, (e.g., explicit definitions of environmental policies, or process designs focused on reducing energy and natural resources consumption in operations; González-Benito & González-Benito, 2005). By underlining a clear relationship between GHRM and firms' EP, this study shows managers alternative practices to those traditionally considered to reduce environmental impact.

Finally, managers should be aware that the role of individualism, masculinity, and long-term-orientation country culture dimensions varies depending on the considered outcomes. For instance, individualism/collectivistic issues are relevant to understanding the relationship between GHRM and GCSM but not when considering the relationship with EP and ECP. These findings should be particularly interesting to managers from companies operating in different countries. National culture issues could mean that results from the same GHRM practices have a different strength depending on the country where the practice is implemented.

5.3. Limitations and future research lines

This research concludes that GHRM contributes to improving ECP directly and indirectly through GSCM and EP. Nevertheless, the studies we examined considered a wide range of GHRM practices. When managers implement GHRM practices, the obtained results could be different from the present ones, depending on the considered practices.

Although the meta-analysis we performed contributes to providing solid empirical generalisations regarding the findings, future meta-analytic research focused on particular GHRM practices could be useful in showing which of them has a major impact on the considered outcomes of organizations (Jackson, 2022). This approach would require sufficient studies to report the relationship between the selected practice and outcomes.

Second, scholars have acknowledged different approaches to GSCM, including functional (e.g., Geng et al., 2017, Zhu et al., 2007, Zhu and Sarkis, 2004), collaborative (Vachon & Klassen, 2006), sustainable supply chain (e.g., Pagell and Shevchenko, 2014, Schaltegger and Burritt, 2014, Seuring and Müller, 2008), and integration

approaches (Han & Huo, 2020). The considered practices vary under each approach.

Revised studies in this research mainly considered GSCM practices under a functional view, which is the most common approach (Han & Huo, 2020). Because prior research has considered a wide number of GHRM practices as well, we believe that limiting the number of examined GSCM practices could help provide results to managers that are useful from a practical perspective. However, future meta-analytic research could consider additional GSCM practices commonly used under other theoretical approaches.

Third, the proposed research model focused on two environmental (GSCM and EP) and one economic (ECP) consequence of GHRM. The model could be expanded to include other variables. However, meta-analytic techniques require sufficient relevant studies for all the pairs of relationships included in the research model. The lack of sufficient studies did not allow us to include other interesting environmental outcomes, such as pro-environmental behaviors. This would not have been a problem if the research model had included only environmental outcomes. However, we believe that examining the relationship between GHRM and ECP is a key strength of this research. Furthermore, the research model was completed with different moderators, which sheds light on the impact of cross-study variance.

Fourth, some studies included in this meta-analysis used self-reports to assess GHRM practices and considered outcomes. Although most of them examined the existence of common-method bias, common-method bias issues could not be totally solved. Moreover, most of the examined studies had cross-sectional designs, which make it impossible to examine the evolution of the studied variables. Future meta-analyses could assess whether longitudinal research designs influence the estimate of the effect sizes if longitudinal studies are performed.

8. Conclusion

Finally, the negative moderating effect of the number of dimensions of GHRM when considering ECP as outcome, although unexpected, could suggest future lines of research regarding complementarity among GHRM practices.

This meta-analysis provides valuable insights into the intricate relationship between green human resource management (GHRM) practices and organizations' economic performance (ECP). The comprehensive examination of 138 effect sizes from 75 studies reveals a positive and significant correlation between GHRM and ECP, both through direct and indirect pathways involving environmental performance (EP) and green supply chain management (GSCM).

The study underscores the nuanced nature of these relationships by identifying contextual and methodological moderators. Contextual factors such as industry type, dimensions of national culture (individualism, masculinity, and long-term orientation), and methodological considerations like the number of GHRM dimensions were found to influence the dynamics of GHRM's impact on ECP.

These findings emphasize the importance of aligning GHRM practices effectively and recognizing the distinct contributions of different GHRM practices in fostering economic performance. Moreover, the study highlights the influence of national culture on GHRM effectiveness, emphasizing the need for a tailored approach based on contextual and methodological considerations. Overall, the research contributes to a deeper understanding of the role of GHRM practices in shaping organizational economic outcomes and underscores the need for strategic and culturally sensitive implementations of these practices.

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Note: (*) Articles that compose the data set for the meta-analysis.

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Predicting Peak Sales Periods for New Product Releases: A Reliable Service for Product Managers

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1. Abstract

Managers dealing with new products need to forecast sales growth, especially the time at which the sales would reach the peak, known as the peak sales time (T*). In most cases, they only have a few initial years' data to predict T*. Although product managers manage to predict T*, there is no method to date that can predict T* accurately. In this paper, we develop a new metric based on the diffusion modeling framework that can help in assessing the prediction accuracy of T*. This metric is built on the premise that observed sales growth is affected both by the force that systematically varies with time and by the non-systematic random forces. We show that the two forces must be carefully combined to assess if a predicted T* is accurate enough. In addition, we empirically prove the efficacy of the proposed metric.

2. Introduction

Until the 1990s, much of academic research in marketing revolved around proposing a theoretical model to explain an observed marketing phenomenon and proving the efficacy of the model with the empirical data pertaining to the phenomenon. Theory was the principal focus, an in-sample empirical fit being secondary. A classic example is the Bass model (Bass, 1969) where a diffusion theory was proposed to explain the new product sales-growth pattern, which was empirically tested with multiple data sets. In such theory-based research, the predictive ability of the model was not the major focus. However, in recent decades, with the advent of real-time big data, there has been a shift in managers' thinking: the predictive ability of a model has become more important. In the light of the shift, modelers have been employing analytical tools such as ANN (artificial neural networks), AI (artificial intelligence), and ML (machine learning), and developing model-based algorithms primarily focused on their predictive ability. In other words, the objective of developing a model has shifted from pure theoretical prediction or explanatory aspects to feasible predictive performance.

Applying this shift in the perspective of a manager to the case of new product marketing, managers would like to predict, for example, the success of a new product before launch or the time when its sales would reach the peak. In our research, we focus on peak sales time, which is defined as the point in time when sales grow to a peak and then level off at some magnitude lower than the peak (Bass, 1969, p. 215). It is typically denoted by T*.

Interestingly, marketing researchers have not paid much attention to T* prediction. Fortunately, in the diffusion literature a strong theory for the existence and location of T* has been established. Starting from Mansfield (1961) and then Bass (1969), it has been shown that almost every new durable product's diffusion in a marketplace experiences two factors as their sales grow in the market, one of them being word-of-mouth (WOM) and the other being market saturation. We expect the sales to grow initially (when WOM is stronger than market saturation) and then decline (when market saturation starts dominating), and the transition point is T*. At T* sales reach the peak, and then start to stabilize or decline.

3. Marketing Analysis

Marketing researchers have developed various models, for example Bass, 1969, Bass et al., 1994, over the past six decades to capture these two factors in the diffusion process, and a few of them yield a closed-form solution, i.e., a direct function for T*. If we have such a diffusion model that gives T* as a direct function of time, we can theoretically

"link" the initial periods' sales data to T* in two steps. In the first step, the model is regressed on the initial years' data (i.e., pre-peak sales data) to estimate the parameters of the model, and in the second step, the parameter estimates are used to estimate T* using the functional form of T*. Thus, a closed-form solution is good to have for prediction purposes because it avoids unnecessary complications like cascading errors encountered in stepwise iterative prediction.

However, a challenge faced here is that the number of initial years' data is usually small—anywhere between 5 and 10—and hence any noise associated with those few data points would seriously affect the accuracy of T* prediction. Note that noise in a data point refers to those disturbances that are not captured by the diffusion model. Given this challenge, a key question that arises is: Would that T* estimate be accurate enough for a manager to plan for the new product launch and act on it?

The question of accuracy becomes challenging because there are two forces influencing the growth dynamics. One is the diffusion force, which is captured by an analytical model, and the other is the market noise. Unless the manager understands the relative influence of each of these two factors, it is difficult to judge the accuracy of the predicted T*. We propose a theoretical metric that captures the relative impact of these two forces.

In this research, we contribute to the diffusion literature in the following ways. First, we focus on prediction of peak sales time T*. Although T* is strategically important for a firm to make decisions concerning production, inventory level, and marketing, it has not received much attention from researchers in the field of marketing. As presented in Table 1, diffusion researchers have focused on developing theoretical models that could explain the observed sales growth data patterns of new durable goods. When the in-sample fit analysis provided sufficient evidence to support their proposed model, researchers used one-step-ahead forecasting for additional support (Lattin and Roberts, 1989, Young, 1993, Meade and Islam, 1995).

Research Articles	Focus	Data Length	Type of Product	Key Results
Young, 1993	One-step-ahead sales forecasts and 3-step-ahead sales forecasts	Data length can be inferred to be around 15.	Not mentioned	Bass model performs better if data have only pre-peak sales data.
Bass, Krishnan, and Jain, 1994	One-step-ahead sales forecasts	10 to 13 periods	Household consumer durables	Generalized Bass Model performs better than Bass model in forecasting, but it has additional explanatory variables.
Meade and Islam, 1995	Sales forecast over 10–11 years	30 years for national data or 72 quarters for regional data	Adoption of telephones (PBX and PBAX systems)	Simple models (models with 2 or 3 parameters) are better than complicated models (models with 4 parameters).
Hardie, Fader, and Wisniewski, 1998	Forecasting of weekly cumulative trials	52 weeks (13 – 26 weeks calibration period)	Consumer Packaged goods	Simple models are better for forecasting, while complex models are better for calibration data fit.
Meade and Islam, 1998	Comparison of different models in terms of model fit and one-step-ahead sales forecasts	Varied (14–46 time periods)	Multiple product categories	Forecast obtained by combining forecasts from different models weighted by fit and stability of the constituent models performs better than forecasts of individual models.
Bass, Jain, and Krishnan, 2000	One-step-ahead sales forecasts	10–13 periods	Household consumer durables	Proportional Hazard model outperforms Generalized Bass model in forecasting.
Bewley and Griffiths, 2003	Forecasting penetration	13 years	CD penetration in 12 countries	Box-cox transformation variant of the FLOG (flexible logistic) model is better for forecasting.
Trusov, Rand and Joshi, 2013.	Pre-launch sales forecasts	Daily data for 4–8 months	Simulated data and Facebook apps	If market conditions are stable, network structure extracted from historical data can help improve predictions.
Toubia, Goldenberg and Garcia, 2014.	Forecast penetration	Uses individual-level data, tracking 398 consumers for weeks on social interaction	Consumer durables	Proposed method does better in forecasting than the traditional models but social interactions data need to be collected, which may not be readily available.
Xiao and Han, 2016	One-step ahead and k-step ahead forecasts using network analysis, also called agent-based model (ABM), that are built using social media and big data	Multiple periods	Consumer durables	ABM network predicts better than traditional models (Bass, Weibull, etc.) in one-step ahead forecasts but they are not manager-friendly yet.
Ramírez-Hassan and Montoya-Blandón, 2020	Pre-launch sales forecast (one-step-ahead and total market size).	0 to 11 time periods for performance comparison	Simulated data sets; consumer durables and natural gas market	Information on similar products or homogeneous markets can be used to forecast sales (and even pre-launch forecast) using Bayesian approach.

Table 1. Review of Sales Forecasting in the Diffusion Literature.

#	Product (j)	First-use Decade	Observed T^* (Year …)	No. of Data Sets (T^*–5+1)	No. of Usable Data Sets
1	Answering machine	1980	9	5	4
2	VCR	1980	20	16	13
3	Desktop PC	1990	12	8	7
4	Fax machine	1990	11	7	7
5	Cordless phone	1980	14	10	10
6	DVD player	2000	9	5	5
7	Digital camera	2000	10	6	5
8	CD player	1990	16	12	11
9	Cell phone	1990	15	11	8
10	Digital TV	2000	13	9	9
11	Cell-Finland	1980	12	8	8
12	Internet-China	2000	12	8	8
13	Cellphone-China	1990	14	10	10
14	Printer	1990	13	9	4
15	Cellphone-India	2000	10	6	6
16	iPhone	2000	9	5	5
17	Fitbit	2010	7	3	3
18	Smartphones	2000	12	8	7

Sum=146 Sum=130.

Table 2. Products Used in Empirical Analysis.

Two other interesting findings have emerged from Table 1: (i) Simple models are generally better than complex models for sales forecasting. (ii) A forecast that is a weighted combination of forecasts from a few carefully chosen models outperforms the forecast from any individual model in the group (Meade and Islam, 1995). However, there is no clear procedure that can be developed from the findings to extrapolate the sales forecasts to T* prediction.2

The second contribution is a metric that we propose to enable managers to assess the accuracy of the predicted T*. We develop a theoretical formulation for the metric using the diffusion framework. Interestingly, the proposed metric is not limited to any specific diffusion model. However, we apply it to the well-known Bass model for demonstration purposes, allowing managers to use this framework on any diffusion model for a given application. We further use multiple data sets to offer empirical

support for the proposed metric's ability to assess the accuracy of a predicted T*. Investors and product managers can use this metric and make more informed decisions on their new product marketing strategies.

The rest of the paper is organized as follows. In Section 2, we present the importance of knowing T* in new product marketing and show how the proposed framework contributes to the literature. In Section 3, we develop the metric to assess the accuracy of a predicted T* and derive a functional form for it. In Section 4, we provide empirical support and in Section 5, we provide guidelines useful to managers derived from our empirical data.

In the 2004 Management Science article, Frank Bass, writing a commentary on his hugely successful model, mentioned the following (Bass, 2004, p.1834):
"… [In 1966] I decided to try my luck at forecasting the sales of color television…Sales data were available for three years: 1964, 1965 and 1966… The result was a forecast that color television sales would peak in 1968 at 6.7 million units…Industry people were more optimistic… As it turned out, color television did peak in 1968 but at a level slightly lower than my forecast… The industry had built capacity for 14 million color picture tubes and there was substantial economic dislocation following the sharp downturn in sales following the 1968 peak…"

The above incident, as explained by Bass, clearly shows the importance of accurately predicting the peak sales time (T*) for a firm, especially for its production and operations planning department. If we notice carefully, the incident talks about over-capacity for picture tubes, an important vendor-component of the television those days. This implies that an inaccurate forecasting of T* can affect not only the company marketing the new product, but also the whole set of vendors supplying various components to the company.

The Bass (1969) article set the stage for a large stream of research to start flowing, which is continuing until now unabated. Particularly, the T* prediction that Bass boldly made for the color television helped in this cause immensely. For an excellent summary of the various modeling developments and ideas in new product sales research, see Meade and Islam (2006).

Ho, Savin, and Terwiesch (2002) analyzed in detail the operations and production issues concerning a new product and derived optimal pre-production level, production capacity, and launch time for the new product. They assumed that T* was known and thereby derived the optimal policies. Negahban and Smith (2018) extended the optimal production capacity issue to the case of multiple generations, which further supported the importance of knowing T* for each generation.

One of the important frameworks that academicians and practitioners use is the product life cycle. It has been demonstrated that a firm should change its marketing strategies when a new product enters the maturity stage, i.e., close to T*. (Kotler and Keller, 2016) This is important also from a competition perspective because at the maturity stage, the competitors start indulging in price-based competition, leading to lower profits for all the players in the marketplace. This further suggests that the firms should predict T* carefully.

Many new products and services launched by firms today are generally improved versions of earlier forms and today's products will be replaced by newer offerings soon. Familiar examples include, Apple's iPhone and iPad, Samsung's Galaxy, Kellogg's breakfast cereals, and Pepsi's healthy snacks. Of the many issues surrounding multi-generational products, market entry timing decision for a new generation has continued to attract the attention of researchers and practitioners over the recent years (Wilson and Norton, 1989, Mahajan and Muller, 1996, Prasad et al., 2004, Kalish and Lilien, 1986, Moorthy and Png, 1992, Krankel et al., 2006, Qin and Nembhard, 2012, Negahban and Smith, 2018, Jiang et al., 2019, Schwarz and Tan, 2021, Bersch et al., 2021). Timing of introduction of a new generation is of strategic importance because a new generation has the potential to cannibalize the sales of the current product, and, given the large investment in developing a new product, there might be financial risks associated with premature or delayed introduction (Mahajan and Muller, 1996).

Researchers have found that the optimal time for introducing a new generation depends on when the current generation is going to peak. Hence, an accurate prediction of T* would lead to better financial decisions and enhance the firm's profitability. An example that illustrates the role created by T* is presented by Jain and Rao (2020) regarding the launch timing of revised textbooks. Jain and Rao (2020) provides a simple framework for determining the optimal timing for a new textbook revision, while the current version would still be selling in the secondary markets as used-text books. The publisher would like to have the current version in the market long enough to recover as much profit as possible realizing the negative effects of the used book sales. Jain and Rao (2020) suggests that before launching the textbook, publishers should estimate the size of the potential market for the new version. Since by the peak sales time, approximately 50 % of the market would have purchased the book, Jain shows that the new and revised edition be launched at peak sales time or anytime soon after that. This example clearly highlights the importance of knowing, i.e., predicting T* in determining the optimal market entry timing for successive generations of new products.

It is rather intriguing that despite the importance of knowing or predicting T* in the areas of Operations and Strategic Marketing, research articles simply assume that T* is known and go about deriving optimal strategies. If firms use a T* that is not accurate, they are likely to encounter such major issues as faced by the color television industry in the last century. In this research, our objective is to propose a metric that will help managers assess if a predicted T* is accurate and hence reliable.

4. Competitive Analysis

Our model development rests on the following premise: if early years' sales data carry a strong "signal" and, moreover, are affected least by "random noise", one would be able to make a more accurate prediction of T* using the evolution process of those sales data points. In a given data set, we can observe how far the signal overwhelms the noise, prompting us to claim that a high Signal-over-Noise ratio might indicate a high predictive ability.

In the context of the sales growth of new products, the signal is the diffusion force, which is powered by the voice of the adopters through WOM. Hence, we paraphrase the Signal-over-Noise as Voice-over-Noise (VON) for the purposes of our research.

A key question is: how to measure this VON ratio?

We need a metric that can give us the VON ratio in a given data set as it pertains to the predictive ability. To devise the new metric, we judiciously use the diffusion theory that underlies the new product sales growth pattern and the noise level in the data set.

With a product experiencing a non-linear, systematic sales growth that has a natural peak, the time to peak and the average growth rate until that peak are related to each other uniquely.

Proof: Let r denote the average periodic growth rate in the interval [0, T*]. Let S(0) be the sales at the launch time, i.e., t = 0, and S(T*) be the sales at the peak, T*.

We are not making any inference on what S(0) or S(T*) is. No mathematical formulation or link between the two is assumed at this point.

We assume the existence of a peak due to the S-shaped curve commonly observed in the sales of new products (Chandrasekaran and Tellis, 2018).

The growth rate, r, assumes near-monotonicity of sales growth.

4.1 New product sales growth rate, r

Let us look at the forces that influence the observed sales growth rate, r. As explained earlier at the beginning of this section, we focus on two forces, namely, Voice of the adopters and the Noise in the data set. Let us call them simply the Voice(V)-Force and Noise(N)-Force We explain each force now.

V-Force: It has been well documented, starting from as early as the 1962 findings of Everett Rogers(Rogers,1962), that WOM plays a critical role in the new product adoption rate. As more and more people adopt the product, WOM increases leading to more adoptions, and thus WOM

monotonically grows with time. However, given that there are only a finite number of first-time adopters for a given product, with every adoption the yet-to-adopt market shrinks, and this shrinking happens monotonically with time. Thus, at a given point in time in the [0, T*] interval, the growth rate is influenced by two forces, namely, WOM and yet-to-adopt market size, both of which are monotonic functions of that time but in opposite directions. We call these forces that vary systematically over time V-Forces.

When Bass (1969) formulated his famous diffusion model to accommodate these two forces in an elegant mathematical framework, he obtained new product sales as a function of just one independent variable: time t. As an empirical proof of how the V-Force lends such power to the time variable, Bass (1969) and, later, scores of other researchers fitted the Bass model to sales data of hundreds of different new products and almost always found the fit to be very good, yielding significant estimates for the Bass model parameters and proving that the natural time explains the underlying pattern of the sales growth of a new product well.

Bass, Krishnan, and Jain (1994) wondered how the Bass model was able to successfully explain the sales growth of a new product without including marketing mix variables. They came up with the explanation that in many cases, the effect of marketing mix variables got subsumed in the time variable. This can happen, for example, when:

Firms decrease price at a constant periodic rate owing to technological improvements and/or economies of scale.

Firms decide on their advertising budget as a constant percentage of the sales revenue of the previous year.

Thus, the V-Force also includes all those effects that vary systematically with time and hence could be empirically captured by the Bass Diffusion Model.

N-Force: The second force that influences sales growth occurs non-systematically with time. This includes the effect of marketing mix variables that are sporadic and other random factors. The nonsystematic marketing mix variables include promotions offered for a certain period to clear the inventory and seasonal events like Black Friday during Thanksgiving. Stores offer special promotions and also try to get the attention of consumers through displaying the new product at the beginning of an aisle or in a focal place within the retail store. We call this the N-force to indicate its nonsystematic nature3.

To summarize, the V-Force has three components, namely, WOM, yet-to-adopt market (i.e., untapped market potential), and time-varying marketing mix variables. The V-Force gives the trend to the sales growth rate. Since the N-Force has no systematic pattern, it can be treated as a discrete noise term at a given point in time.

Since the N-Force is a nonsystematic discrete noise term, we assume it to be a random variable. Noting that the annual sales of a new consumer durable grow from hundreds in the launch period to millions at T*, it is prudent to include the nonsystematic component multiplicatively, i.e., proportionally to the systematic component (Van den Bulte and Lilien, 1997, Venkatesan et al., 2004, Niu, 2006). Tian et al. (2013) have demonstrated analytically that a multiplicative error model is better than an additive formulation, especially when large-range data sets are involved, which is true of typical diffusion data sets. Consequently, we propose:

$S(0) = SV(0) \bullet SN(0)$ (3) Taking the log on both sides of both the expressions in Equation (3), we get: $\text{Ln}[S(0)] = \text{Ln}[SV(0)] + \text{Ln}[SN(0)]$ (4) In Equation (4), $\text{Ln}[SN(0)]$ follows the normal distribution when we assume $SN(0)$ to follow a log-normal distribution with mean 1 and variance $\exp(\sigma 2) - 1$, in line with the multiplicative inclusion of noise. The corresponding normal distribution will have mean $(-\sigma 2/2)$ and variance $\sigma 2$. Similarly, we can split $S(T^*)$ as follows. $\text{Ln}[S(T^*)] = \text{Ln}[SV(T^*)] + \text{Ln}[SN(T^*)]$ (5) where $\text{Ln}[SN(T^*)]$ is normal error with mean $(-\sigma 2/2)$ and variance $\sigma 2$. We get:

$\text{Ln}(S(T^*)\, S(0)) = \text{Ln}(SV(T^*)\, SV(0)) + \text{Normal}(0, 2\sigma 2)$

because the mean of the differences between the two normal error terms that are IID is zero, and the variance of that difference is the sum of the two variances4.

Having expressed the starting point (t = 0) and end point (t =) of the sales growth in terms of V-Force and N-Force, we now substitute Equation (6) in the growth rate Equation (2) to get:

Ln(1 + r) = 1 T* Ln(S(T*) S(0)) = 1 T* Ln(SV (T*) SV (0)) + 1 T* Normal(0, 2σ2) (7)

The first term on the right-hand side in Equation (7) captures the trend component in the sales growth and so can be adequately explained by a simple but powerful diffusion model like the Bass model. The second term captures the random, discrete spikes on the sales growth curve. The standard deviation of the noise term is ¯2 √ T* σ. It is rather easy to see that the variance or unpredictability of r depends on how far the right hand side of Equation (7) is dominated by the second term.

5. Product Design

We use pre-peak sales data of 18 product categories based on data availability, the time they were launched (before and after 2000), and of time savings and/or entertainment value to the consumers. Every product gives multiple data sets as explained below. Consider a new product whose T* is well beyond 5 years. At the end of the 5th year, the manager can use the 5 years' sales data to estimate the parameters of the Bass model (p, q, and m) and use those estimates to predict T*. Then, at the end of the 6th year, the manager can use the 6 years' sales data to obtain another prediction for T*. The manager can keep coming up with a prediction for T* every year until they reach the T*. Assuming that this product hits peak sales in Year 9, we see that the manager can make five T* predictions, one in Year 5, next in Year 6, …, and the last in Year 9. Thus, every product gives multiple data sets. The products in our analysis range from cordless phones of the 1980s to the smartphones of the 2000s.

Each subset is a sample element in our analysis. Thus, we collected 146 subsets (the sum of column 6 in Table 2) in all. We fitted the Bass model on each sample element for this screening, and out of the 146 subsets, 16 had problems with convergence or suffered from the takeoff phenomenon (Golder and Tellis, 1997),5 and hence were removed, yielding us a net sample size of 130. Column 7 of Table 2 gives the number of usable sample elements. We call this the metaset.

Salesj(t) = (mji)(Fji(t)− Fji(t − 1)) where Salesj(t) is the observed sales of product j at time t, mji is the market potential parameter specific to subset i of product j, and Fji(u) is the cdf (cumulative density function) as given in Equation (12). We included log-normal error multiplicatively in the above expression. Hence, taking the log on both sides, we get: Ln(Salesj(t)) = Ln(mji) + Ln(Fji(t)− Fji(t − 1)) + ε N (0, σ2) (17) We used the nonlinear least-squares (NLS) procedure in SAS for the estimation.6 For each sample element in the metaset, the estimated Bass model parameters, namely {p̂ji, q̂ji, m̂ji}, and their respective standard errors were in turn used to get estimates of: 1.σ̂ji, the noise estimation, the nonsystematic component in the data points, 2.VON̂ji(Equation (16)), the proposed metric to assess the accuracy of the T* estimate, and. T ̂* Ji, the peak sales time as evaluated from the subset's estimates (see Equation (14)).7 Note that while the actual T* j is the same for all the subsets pertaining to product j, the predicted peak sales time,T ̂* Ji, may come out to be different for different subsets in the product j. A key question here is "how high should the VON be to claim that the corresponding predicted T* is accurate and reliable?" We will answer this question in Section 5. We will now see how far our claim regarding VON holds across the 18 categories we tested.

T* it predicts, i.e., T ̂* , and (b) VON, our objective is to assess whether VON is positively associated with the accuracy of the predicted T*, i.e., the deviation of predicted T* from the actual-T*. Accordingly, we use the following regression on the metaset to estimate this influence of VON over the accuracy of T* prediction. Ln(Yji) =β0 + β1Ln(Xji) where Yji =|| T ̂* Ji − T* j||*100/T* j , which measures the deviation in T*-.

The first factor we consider is the number of data points in each subset used in the estimation. Noting that we are dealing with small data sets, addition of even one data point is likely to make a significant impact on the estimation and subsequent prediction. In other words, a subset with six data points would be expected to perform better than one with five data points, everything else remaining the same

across the two subsets. According to the findings in the extant literature, data set length (i.e., the number of data points used in the estimation) affects the estimates (e.g., Lenk and Rao, 1990, Mahajan and Shama, 1986, Parker, 1994, Srinivasan and Mason, 1986, Van den Bulte and Lilien, 1997). Hence, we conjecture that a longer subset (i.e., one with a higher number of data points) will result in better prediction of
. We expect the impact of data set length on the deviation of T* to be negative. We next consider two socioeconomic factors derived from Rogers (1995, p.206).

The communication channels have gotten better over the decades, especially after the Internet was introduced in the late 1980s and the World Wide Web in the mid-1990s. But a breakthrough in WOM communication came in when the social media started going mainstream in the 2000s (Yusuf and Busalim, 2018). The products introduced in the 2000s were likely to have experienced a stronger WOM leading to a larger V-Force, which might have improved the accuracy of T* prediction. Accordingly, we will include in Equation (18) a 'digital WOM' effect (or called the Word-of-Mouse effect8), a dummy for products from 2000 to signal the extra influence they got from social media, blogs, and other new-age communication channels. We expect the 2000s' products to have a negative effect on the T* deviation or inaccuracy.

We have used annual data in our analysis and suggested that managers should wait until there were enough data points for the estimation. A natural question a manager could ask is: Why wait for years if we have access to quarterly data or monthly data? Such a data set has two differences with respect to the annual data. First, the data interval per se is small, and second, for a given period in years, the number of data points available with quarterly or monthly data will be higher. We examine the impact of smaller-interval data in this section, as it pertains to T* prediction.

Since quarterly data or monthly data are not readily available, especially for consumer durable goods like TV and room air-conditioners, we managed to obtain quarterly data for two hi-tech products introduced in the past 15 years, namely, iPhone and Fitbit. These products were regarded as breakthrough technologies and due to their leading positions, they were near-monopolies in their initial years. With each product, we fit the Bass Model to the quarterly data, starting from the 4th or 5th quarter, and we used our previously explained procedure to get the estimates of peak sales time (T*). We repeated the process by adding quarterly data one by one to examine the changes in those estimates and compared them with the estimates obtained using yearly data.

Looking at the results of iPhone, we see that both the quarterly data and the annual data produce very similar values for the predicted T*. This shows that the data interval may not have a major impact on the estimated value of peak sales time. For Fitbit, the predicted values for T* are also similar for both quarterly and annual data sets.11 Given that quarterly and yearly data produce similar T* estimates, but quarterly data has higher noise, we recommend using yearly data for predicting T.12

6. Marketing Plan

The following are recommendations for managers to ensure proper assessment of T* prediction accuracy:
Step 1. The manager should collect as many data points as possible. We recommend using yearly data but if the manager wants to use monthly or quarterly data, they should first smoothen the variation due to seasonality.

Step 2. The manager should pick a parsimonious but established growth model like the Bass model and estimate it on the data set collected (which has at least five data points) using the log–log version (see Section 4.2). If the regression doesn't converge or the estimates are found to be insignificant, then waiting is preferable to gather more data points.

Step 3. If the estimates are significant, the manager should use a Monte Carlo technique and estimate T* (Equation (14)) along with its standard deviation and VON (see Equation (16) and Section 4.2). Depending upon how strict the manager wants to be with the prediction accuracy, they can use Table 6 and decide whether to accept the predicted T* or not.

Step 4: If VON is lower than the threshold-T*, the manager can wait for one more year to collect more data and then repeat the T* prediction exercise.

Step 5. Suppose that the manager is forced to use the predicted T* even though the corresponding VON is lower than the desired threshold level. Based on the analysis on the 18 products in this research, a predicted T* having a VON lower than the threshold-VON indicates that it is likely to have around 50 % deviation with respect to the actual T*. So, the manager must be ready with a backup plan if they continue with the predicted T* and make changes in the strategies.

Step 6. The manager may wish to use another procedure (e.g., survey or analysis of an analogous product in a similar market) to corroborate the T* prediction accuracy.

7. Finance and Fundraising

Of all the forecasts a manager must make with respect to a new product that has found some traction in the marketplace, one of the most important would arguably be forecasting the time when the sales growth would reach the peak, denoted by T* in the diffusion literature. When a new durable is about to reach peak sales time T*, it indicates that the maturity stage is setting in. At this juncture, the firm must change its production schedule, inventory policies, and marketing strategy, and further, work on the next new product to introduce in the marketplace. Given its importance from so many angles, a manager would like to predict T* in advance so that they are able to help the firm get ready on various fronts. Although currently there are quite a few diffusion models available that the manager can use to estimate T* with the pre-peak sales data, there has been no research in the existing literature that can tell them how accurate such a predicted T* is. Assessing the accuracy is a challenging task because we are working with small data sets, i.e., a few early periods' data points.

Through our research, we contribute to the marketing literature by proposing a new metric, VON, and empirically demonstrate how it helps a manager assess the accuracy of predicted T*. We also provide a step-by-step procedure for a manager to adopt this new metric. The proposed metric VON is not limited to specific model specifications. We use the Bass Model only as a demonstration of the metric's usefulness.

There are several key managerial implications. Predicting T* is vital for a firm because as the firm approaches T*, it should focus on its R&D strategy, i.e., whether it should develop a new version now or later; Operations strategy, i.e., whether it should change the production rate, inventory, and supplies from vendors; and Marketing strategy, i.e., whether it should start using price as a tool to attract customers. Furthermore, products introduced in the 2000s (i.e., 2000–2010) seem to yield more accurate T* than those introduced in the 1980s and 1990s, highlighting the special role played by word-of-mouse (i.e., information spread digitally through the Internet, social media, and e-mails) in the post-2000 period in addition to traditional WOM. Lastly, data intervals do not have a major impact on the prediction accuracy, i.e., using quarterly or monthly data doesn't lead to better predictions than yearly data.

There are a few areas for further research. First, our finding on the role of word-of-mouse effect on the products introduced in the post-2000 era is worth further investigation, i.e., further study on how social networks and viral diffusion are contributing to the diffusion process. It would be interesting to know how today's fast and mobile consumer voice affects T* prediction. Second, noting that market noise has been found to play a highly important role in prediction, future researchers can further investigate the noise component and advise managers on remedial actions to be taken to reduce the noise. Third, VON may be used to examine the growth models between different generations of products as well as those in different countries that launch new products at different times. Fourth, the definition of peak-sales time can be looked at from a different perspective. One way would be to measure continually the change in sales rate and have a threshold to define the peak-sales time as something like "if change in sales rate is lower than certain value", then we declare that peak sales is reached. Such definitions would be hard to formulate mathematically but they would be more pragmatic and worth pursuing.

8. Conclusion

The challenge of accurately forecasting peak sales time (T*) for new products confronts managers with limited initial data. Despite their efforts, existing methods lack precision in predicting T*. This paper introduces a novel metric grounded in the diffusion modeling framework to evaluate the accuracy of T* predictions. The metric considers the interplay between systematic forces that vary over time and non-systematic random forces influencing observed sales growth. The study underscores the importance of carefully integrating these forces to assess the reliability of predicted T*. Empirical evidence presented in the paper substantiates the effectiveness of the proposed metric, offering a valuable tool for product managers grappling with the complex task of forecasting peak sales time for new products.

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When Does Celebrity Endorsement Prove Effective? A Plan for Celebrity Endorsers and Strengthening Crucial Brand Associations

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1. Abstract

This study examines how a celebrity endorser's key associations can complement and help improve a brand's low corresponding associations. By conducting three studies, we find that when consumers have no prior knowledge about the benefits of a brand, a celebrity's enabling, enticing, and enriching (3E) associations get transferred to the brand. However, when consumers know that a brand has low 3E benefits, only the celebrity endorsers' enriching associations are transferred to the brand. Thus, from the current study the importance of a celebrity's enriching benefits is emphasized for both unknown and well-known brands. Furthermore, we theorize and demonstrate consumer elevation as the underlying mechanism whereby the enriching benefits of a celebrity endorser are transferred to a brand. The current findings extend the extant literature on celebrity endorsement management and provide valuable managerial insights for developing effective celebrity endorsement strategies.

2. Introduction

Celebrity endorsement marketing has been on the rise globally, and numerous firms devote multi-million budgets to celebrity endorsement annually to leverage brand association by collaborating with celebrities who are well-known or possess a desirable positive image (Aw and Labrecque, 2020, Yu and Hu, 2020). For example, as a global fast-food chain, McDonald's launched the 'BTS Meal' (BTS is a South Korean boy band) across six continents and 50 countries worldwide in mid-2021. McDonald's is estimated to have paid BTS over USD$ 8 million and even abandoned its signature color, red, and replaced it with purple, the color of BTS. The outcome of the campaign was remarkable and helped boost sales worldwide and resulted in an "earning surprise." However, not all endorsement campaigns are as successful, and important questions remain about what type of celebrity associations, if any, get transferred to a brand effectively.

Given the prevalence of promotions featuring celebrities and their endorsements, research on celebrity endorsement has been an important topic in marketing communication strategy (Schimmelpfennig & Hunt 2020). And since celebrities as brand endorsers have been noted as a key secondary source of associations for a brand (McCormick, 2016, Ilicic and Webster, 2013), academic researchers have scrutinized the effectiveness of various endorsement strategies. For instance, it has been noted that celebrity associations may help increase brand awareness among consumers (Aw & Labrecque, 2020; Buttle et al., 2000, Miller and Allen, 2012, Zamudio, 2016) and change brand credibility and attitudes (Amos et al., 2008, Chung and Cho, 2017, Knoll and Matthes, 2017, Liu and Liu, 2019).

Extant work on celebrity endorsement's effect on consumer response and evaluation, however, has mainly focused on the commonality perspective of leveraging associations, emphasizing the importance of fit and congruency between a brand's image and its celebrity endorsers' image (Albert et al., 2017, Pradhan et al., 2016, Rice et al., 2012, Kamins, 1990, Till and Busler, 2000; Zhu et al., 2019). Critical questions remain about the effectiveness of potential complementarity strategies, which suggest that less congruent knowledge about the entity

(celebrity) may also have either a direct or an indirect effect on the target (endorsed) brand (Keller & Swaminathan, 2020).

Although complementarity strategies can be strategically critical in delivering the desired image for a brand, current knowledge about its effectiveness and possibilities remains limited (Chang and Ko, 2016, Lee and Thorson, 2008, Zamudio, 2016). This study aims to fill this critical gap in the existing literature. More specifically, we examine how a celebrity endorser's key association can complement and help improve a brand's weak corresponding association. The current findings show that when the focal brand and its benefits are known to consumers, a celebrity endorser's enabling, enticing, and enriching benefits may all be transferred to the brand. In contrast, when the focal brand is not known to consumers, only the enriching benefit of an endorser is transferred to the brand. Thus, the current results emphasize the critical role of a celebrity endorser's enriching benefits for both known and unknown brands in complementary celebrity endorsement. We further explore the key role of the celebrity endorser's enriching benefits in helping a brand by examining consumer elevation as the underlying mechanism through which such benefits are transferred to an endorsed brand.

The next sections discuss the theoretical background, develop a set of formal hypotheses, and present three studies to test the proposed hypotheses. Finally, we explore the theoretical and managerial implications of the findings and key avenues for future research.

3. Marketing Analysis

Celebrity endorsement has been noted as one of the most prevalent strategies for leveraging secondary brand associations and prior work suggests that leveraging the associations of other entities allows for two types of strategies: commonality and complementarity strategies (Keller & Swaminathan 2020). The former has been noted as an effective strategy for strengthening existing key brand associations (Dimofte & Yalch, 2011; Keller, 2003). In contrast, the latter aims to develop novel desired brand associations by leveraging the associations of the other entity. Hence, it focuses on building new rather than strengthening existing brand associations.

Previous studies on celebrity endorsement have mainly focused on the commonality strategy, which emphasizes the importance of fit and similarity in customer associations between a brand and its celebrity endorsers (Albert et al., 2017, Pradhan et al., 2016, Rice et al., 2012, Kamins, 1990, Till and Busler, 2000; Zhu et al., 2019). Moreover, the importance of fit between the associations of a brand and those of an endorser (Albert et al., 2017, Choi and Rifon, 2012, Escalas & Bettman, 2017; Zhu et al., 2019) has been studied in various contexts such as varying customer involvement, product category, cause-related marketing, consumer-brand congruency, and celebrity-consumer congruency (Arsena et al., 2014, Boon and Lomore, 2001, Choi and Rifon, 2012; McCracken, 1989; Wright, 2016). However, based on the proposed complementarity leveraging strategy, weak or no congruent associations between the brand and the celebrity endorser may also provide strategical effects in delivering the desired brand association. To date, the complementary celebrity endorsement strategy is still an under-explored area. Therefore, by drawing on the 3Es brand benefit theory, in this study we aim to explore the potential of complementarity leveraging strategies, and more specifically, to examine the extent to which brands with certain weak benefits (e.g., weak enabling, enticing, and enriching) can be complemented by the celebrity endorser's strong corresponding (e.g., strong enabling, enticing, enriching) associations to change consumer perceptions.

3.1 Benefits of brands and celebrities based on the 3Es theory

According to prior studies, brand benefits can be classified into three types: enabling, enticing, and enriching benefits (3Es in short) (Park et al., 2016). The 3E benefits are relevant to one or more classes of human needs that underlie key typologies of human motivations, needs, values, and goals. As Krishna (2012) highlighted, brands with enticing benefits offer various sensory and cognitive stimulations that activate customers' thoughts and senses to please them. Brands please the senses when they provide stimulation by arousing the imagination or curiosity. Moreover, they may offer sensory stimulation by activating pleasant experiences, including sights, sounds, tastes, smells,

and tactile sensations (Biswas et al., 2014, Brakus et al., 2009, Eisingerich et al., 2019, Yoon and Park, 2012).

Further, the enabling benefits of a brand are important to consumers as they strengthen consumers' trust in the brand and brand attachment (Park et al., 2013, 2016). Brands' enabling benefits can empower customers and give them a stronger sense of control over their environment by helping them solve small or large problems. Brands may also empower customers by helping them conserve their scarce resources, including time, monetary, psychological, and physical resources (Bell et al., 2017, Eisingerich and Bell, 2008, Lin et al., 2021, Liu et al., 2015, Merlo et al., 2018, Park et al., 2013, Sun et al., 2021). Finally, prior work notes two ways brands can provide enriching benefits: reflecting personal beliefs and hopes and symbolizing one's status and relationships (Berger and Heath, 2009, Foscht et al., 2018, Gill-Simmen et al., 2018, Park et al., 2016, Shavitt et al., 2009). Customers may feel inspired when the brands they purchase and consume daily have values or principles that align with their personal or professional worldview on what is moral, good, just, and right. Brands may also offer enriching benefits to customers by allowing them to signal their values to others (Coleman & Williams 2015). Whereas the lack of enriching benefits may not be a source of major disappointment, their presence might delight consumers, making their impact stronger (Park et al., 2016).

Hence, celebrity endorsers who have established their personal brand image may also possess and provide these 3E benefits. As celebrities can provide enticing benefits through their good looks, voices, and humor, brands often partner with celebrities, hoping that their glamour or pleasing charm is transferred to the brand (Dwivedi et al., 2015). Celebrities also offer enabling benefits that empower consumers. Consumers may trust an endorser because of their enabling benefits, such as expertise and skills in certain product categories, or because they reflect an active lifestyle (Bergkvist and Zhou, 2016, Dwivedi et al., 2015, Knoll and Matthes, 2017, Park et al., 2010, 2016). When doctors and dentists promote toothpaste or toothbrushes, consumers trust them for their perceived expertise in dentistry (Guido et al., 2011, Tripp et al., 1994). Celebrities are considered to embody personality and lifestyle-related meanings (McCracken, 1989). Consumers value the symbolic meanings associated with celebrities and use these meanings, in part, to craft an individual sense of self (Dwivedi et al., 2015, McCracken, 1989).

We posit that the 3E benefits of celebrity endorsers may transfer to and complement the weak corresponding 3E benefits of endorsed brands depending on the level of consumer knowledge about the endorsed brands. The next section develops a set of formal hypotheses on the transfer of a celebrity endorser's 3E benefits to unknown and well-known endorsed brands.

3.2 Transfer of celebrity endorsers' benefits to unknown endorsed brands

The meaning transfer model (McCracken, 1989) suggests that certain celebrities are characterized by cultural meanings that are transferred when they enter an endorsement relationship, such as advertising a product or service. Thus, such cultural meanings that celebrities are endowed with become the cultural meanings of the endorsed product. Accordingly, this study builds on the meaning transfer model. McCracken (1989) describes many celebrity meanings, including status, class, gender, age, personality, and lifestyle. More recently, Miller and Allen (2012) elaborated on the model by applying an evaluative conditioning framework as the cognitive underlying mechanism.

According to De Houwer (2007, p. 230), evaluative conditioning is "an effect, that is, a change in the valence of a stimulus that results from pairing the stimulus with another stimulus." This evaluative conditioning in celebrity endorsement likely occurs with unknown brands rather than well-known brands (Cacioppo et al., 1992, Gibson, 2008, Miller and Allen, 2012) because a rich network of memory associations characterizes well-known brands. Thus, attitudes toward well-known brands are more challenging to change using evaluative conditioning procedures, including celebrity endorsement. In contrast, consumers are likely to perceive the celebrity endorser's benefits as the endorsed brand's benefits through evaluative conditioning procedures when they do not already have a certain perception of the endorsed brand.

Previous studies support this view. Consumers with limited brand knowledge tend to have fewer existing associations with the brand (Czellar & Luna, 2010), which makes them seek additional information to build new associations (Chang & Ko, 2016). In the process, consumers tend to be more influenced by information that is effortlessly accessible (Petty et al., 2007). For instance, consumers are likely to build associations with the unknown endorsed brand by using information they have about the celebrity endorser. Hence, consumers' attitudes toward unknown endorsed brands, compared to well-known endorsed brands, are more likely to change through celebrity endorsement. Based on the above, we predict that an endorser's benefits can help build the corresponding benefits of the endorsed brands when consumers have no information about the endorsed brands' benefits. Formally, we hypothesize that endorsers' enabling, enticing, and enriching benefits transfer to brands with benefits unknown by consumers:

H1a: A brand with benefits unknown to consumers will be perceived as having higher enabling benefits when a celebrity endorser has strong enabling benefits.

H1b: A brand with benefits unknown to consumers will be perceived as having higher enticing benefits when a celebrity endorser has strong enticing benefits.

H1c: A brand with benefits unknown to consumers will be perceived as having higher enriching benefits when a celebrity endorser has strong enriching benefits.

While we expect that a celebrity endorser's 3E benefits are all transferred in the case of endorsed brands with benefits unknown to consumers, we propose that different outcomes likely occur for endorsed brands with benefits well-known to consumers. According to prior studies, enriching benefits are non-product-related, whereas enabling and enticing benefits are often perceived by consumers as product-related (Keller, 1993, Park et al., 2016). As product-related attributes are "the ingredients necessary for performing the product or service function sought by consumers" (Keller, 1993, p. 4), customers may experience such benefits from the product attributes (Ford & Nichols, 1987). Enabling benefits empower customers by helping them conserve their scarce resources (Park et al., 2016). Since the benefit is an attribute related to the expertise in solving consumers' problems, consumers may perceive the benefit through the product's actual usage. This indicates that the enabling benefits correspond to the actual function of the product itself. Likewise, enticing benefits satisfy sensory pleasure and provide cognitive stimulation from using a product or service (Keller, 1993). Because sensory pleasure such as visual, auditory, olfactory, taste, and tactile is perceived through the inherent attribute of a product or service, the enticing benefits also correspond to the actual feature of the product itself. As consumers may feel the enabling and enticing benefits from the product itself because they are intrinsic by nature, enabling and enticing benefits are unlikely to be experienced simply by leveraging other secondary sources, such as celebrity endorsement, when consumers know the product is lacking in those benefits.

By contrast, non-product-related attributes are "external aspects of the product or service that relate to its purchase or consumption" (Keller, 1993, p. 3). Thus, enriching benefits of brands are extrinsic by nature, unlike enabling and enticing benefits, as enriching benefits are not necessarily experienced with the product attributes. Enriching benefits, which are non-product-related, may be delivered by leveraging secondary sources even though consumers know the product lacks those benefits. Supporting this view, Escalas and Bettman (2009) empirically demonstrate that celebrity endorsement of brands is a source of symbolic brand meaning, which provides symbolic and inspiring benefits to consumers.

Cognitive dissonance theory (CDT) supports this argument. Specifically, CDT suggests that individuals feel a psychologically unpleasant state called cognitive dissonance when they experience two or more contradicting cognitions. Thus, they tend to resolve the discomfort by altering their cognitions (Festinger 1957). Individuals may choose their attitudes, behaviors, or beliefs by altering cognitions to reduce cognitive discrepancy, which helps restore cognitive consistency (Chang and Ko, 2016, Hinojosa et al., 2017, Jeong et al., 2019). In the process of discrepancy reduction, CDT predicts

that individuals alter the cognitions that are the least resistant to change (Festinger, 1957). Enabling and enticing benefits are intrinsic product-related benefits that need to be experienced with the attributes of the brand offering. Hence, based on CDT, we expect that consumers likely reject new cognitions from a celebrity endorser with strong enabling or enticing benefits when they know the endorsed brand lacks those benefits because their existing cognitions are resistant to change. In contrast, enriching benefits are extrinsic non-product-related benefits that are not relevant to the attributes of the brand's offerings. Hence, we expect that a celebrity endorser's well-known strong enriching benefits get transferred to the brand even when consumers know the endorsed brand lacks enriching benefits. Formally, we posit that:

H2a: A brand with known low enabling benefits will not be perceived as having higher enabling benefits even though a celebrity endorser has strong enabling benefits.

H2b: A brand with known low enticing benefits will not be perceived as having higher enticing benefits even though a celebrity endorser has strong enticing benefits.

H2c: A brand with known low enriching benefits will be perceived as having higher enriching benefits when a celebrity endorser has strong enriching benefits.

4. Competitive Analysis

Elevation, also known as moral elevation, is a distinct positive emotion experienced when an individual witnesses another person engaging in a virtuous act, particularly one that enhances the welfare of others (Algoe and Haidt, 2009, Haidt, 2003a, Haidt, 2003b, Keltner and Haidt, 2003, Thomson and Siegel, 2017). Prior research has noted elevation as a discrete emotion, separate from a general positive mood (Haidt, 2003a; Schnall et al., 2010). The cognitive appraisal theory of emotions posits that discrete emotions arise from the evaluation and interpretation of events, rather than the events themselves. The theory identifies various types of discrete emotions (Arnold, 1960, Lazarus, 1968, Roseman, Spindel, & Jose, 1990, Watson & Spence, 2007), but elevation is not fully studies in this regard. Extant emotion literature posits that emotions initiate a series of responses, including physiological and behavioral changes (Lerner and Keltner, 2000, Levenson, 1994). Furthermore, emotions exert a direct motivational influence, potentially altering goal prioritization (Schwarz & Clore, 2007). In accord with this, studies have demonstrated that elevation fosters a desire to improve oneself (Haidt, 2000; Aquino et al., 2011) and collaborate with others (Algoe & Haidt, 2009), as well as promotes prosocial behaviors (Schnall et al., 2010, Schnall and Roper, 2012). To further substantiate elevation as a discrete emotion, previous research has explored its physiological consequences. Piper et al. (2015) reported that elevating experiences increased heart rate and respiratory sinus arrhythmia, while Silvers and Haidt (2008) found that elevation in mothers correlated with elevated oxytocin levels and lactation.

According to Algoe and Haidt (2009), elevation is one of the other-praising emotions, which also includes admiration as it is elicited from witnessing others' exemplary actions. Although elevation and admiration are part of the other-praising family of emotions, they may motivate people differently. It is because elevation is an emotional response to moral excellence whereas admiration is an emotional response to non-moral excellence such as extraordinary skills, talent, or achievements. As a result, elevation motivates people to be kind to and caring about others while admiration motivates people to work hard toward success (Algoe and Haidt, 2009, Haidt, 2000, Haidt, 2003a). As elevation is an emotional response to moral excellence, we do not expect consumers to feel elevated by celebrities with strong enabling or enticing but weak enriching benefits. Enabling benefits may stem from expertise and skill of the celebrities and enticing benefits may stem from physical appearance, beautiful voices, charm, with and humor of the celebrities that are not related to moral excellence. In addition, the feeling of elevation also fits well with the broaden-and-build model of positive emotion (Fredrickson, 2000, Haidt, 2000). As celebrity endorsers with enriching benefits induce elevating experiences of consumers, their momentary thought-action repertoires broaden to feel the same enriching benefits from the endorsed brands. Thus, we propose the following hypothesis:

H3: The feeling of elevation from an endorser's enriching benefits mediates the transfer of an endorser's enriching benefits to the endorsed brand.

We conducted three studies to test our proposed hypotheses. Study 1 examined how the 3E benefits of celebrity endorsers complement and help build the corresponding 3E benefits of an endorsed brand when the brand benefits are unknown to consumers. Study 2 examined the same complementary effects of celebrity endorsers' 3E benefits when the brand benefits are known to consumers. Study 3 shows the generalizability of Studies 1 and 2 by confirming the results with a different focal brand, different endorsers and participation samples from a country with a different cultural background. Further, we tested the mediation role of the feeling of elevation in the transfer process with Study 3.

Study 1 examines to what extent an endorser's benefits can be transferred to a brand that consumers do not know its benefits (H1). First, we conducted 26 in-depth, semi-structured interviews with participants of a university course to identify three types of celebrity endorsers who are solely strong in one of the 3E's: (1) a celebrity with high enabling (and low enticing and enriching) benefits, (2) a celebrity with high enticing (and low enabling and enriching) benefits, and (3) a celebrity with high enriching (and low enticing and enabling) benefits, respectively. Interviews lasted, on average, 35 min. Each participant received USD 25 as a token of gratitude, was debriefed, and did not further participate in the study. Further, to set an unknown brand condition, we created a fictitious new coffee machine brand called "Mardi," which was used as the brand stimulus because the product category has reasonably high consumer involvement and is not gender- or age-specific (a pre-test (N = 89) showed that consumers of varying age and gender were equally interested in coffee makers).

Selecting celebrity endorsers. Three pre-tests (N = 30, N = 31, and N = 31) were conducted to select three celebrities high in one (and low in the other two) of the three key benefits. Accordingly, we got Ben Stiller for the celebrity with a high enticing benefit (Menabling = 2.89, Menticing = 7.53, and Menriching = 3.17, $p < .05$); Lucy Liu, with a high enabling benefit (Menabling = 7.42, Menticing = 3.54, and Menriching = 3.50, $p < .05$); and Whoopi Goldberg, with a high enriching benefit (Menabling = 3.26, Menticing = 3.47, and Menriching = 7.72, $p < .05$).

5. Product Description

Respondents and procedures. As part of a regular course requirement at their University, 380 students (female 57 %) participated in Study 1. Respondents were randomly assigned to one of four conditions: the experimental conditions with Lucy Liu, Ben Stiller, and Whoopi Goldberg, and the control condition with no endorser. Since we aimed to examine a brand with benefits unknown to consumers, we did not provide specific information about the focal brand except for the name "Mardi." Specifically, we created a one-page magazine commentary purportedly in the "New Tech" section, which introduced the fictitious espresso coffee machine brand "Mardi," without any information about the 3E benefits from the brand. Study 1 was conducted across two time periods; at Time 1 (stimulus without any celebrity endorsers) and Time 2 (stimuli with the three types of celebrity endorsers and no endorser) to ascertain whether the celebrity endorsers' benefits transfer to the brand' Mardi.' We employed a two-time within-subject design to examine the changes in respondents' perception toward 3E benefits before and after exposure to a celebrity endorser. Accordingly, at Time 1, respondents were only exposed to the brand category and brand name "Mardi." Specifically, the participants were asked to see the one-page magazine advertisement introducing Mardi and answer questions about the enabling ($\alpha = 0.81$), enticing ($\alpha = 0.85$), and enriching ($\alpha = 0.80$) benefits of Mardi, adapting the published brand enabling, enticing and enriching measures from Park et al. (2013, 2016) and using a seven-point Likert scale (1 = strongly disagree, 7 = strongly agree). Although we did not provide any information on the benefits of "Mardi," measuring the levels of these benefits is essential to compare them at Times 1 and 2. Table 1 reports detailed measurement items.

Measures	Items	Study 1		Study 2		Study 3	
		T1	T2	T1	T2	T1	T2
Endorser enabling benefit	X has benefits that make me feel empowered		0.96		0.98		0.86
	X has benefits that make me feel efficacious						
	X has benefits that make me feel capable						
	X has benefits that make me feel resourceful						
	X has benefits that make me feel protected						
Endorser enticing benefit	X has benefits that are fun to look at		0.80		0.98		0.89
	X has benefits that arouse pleasant visual, auditory sensations or experiences						
	X has benefits that gratify my visual or auditory senses						
	X has benefits that make me feel stimulated						
Endorser enriching benefit	X has benefits that express my identity		0.94		0.98		0.85
	X has benefits that reinforce my values and beliefs						
	X has benefits that provide a sense of inspiration						
	X has benefits that make me feel special						
	X has benefits that make me feel proud						
Brand enabling benefit	The brand has benefits that make me feel empowered	0.81	0.91	0.98	0.98	0.94	0.93
	The brand has benefits that make me feel efficacious						
	The brand has benefits that make me feel capable						
	The brand has benefits that make me feel resourceful						
	The brand has benefits that make me feel protected						
Brand enticing benefit	The brand has benefits that are fun to look at, taste, touch, smell, experience, or consume	0.85	0.86	0.97	0.98	0.94	0.91
	The brand has benefits that arouse pleasant visual, auditory, gustatory, tactile, or olfactory sensations or experiences						
	The brand has benefits that gratify my visual, auditory, gustatory, tactile, or olfactory senses						
	The brand has benefits that make me feel stimulated						
Brand enriching benefit	The brand has benefits that express my identity	0.80	0.91	0.98	0.98	0.89	0.90
	The brand has benefits that reinforce my values and beliefs						
	The brand has benefits that provide a sense of inspiration						
	The brand has benefits that make me feel special						
	The brand has benefits that make me feel proud						
Brand relevance	How interested are you in X?	0.72		0.84		0.65	
	How relevant is X to you?						
Attitude toward endorser	I have very positive feelings toward X.		0.89		0.96		0.91
	My impression of X is very bad. (reverse coded)						
	I have negative feelings toward X. (reverse coded)						
	I have very favorable feelings toward X						
Fit between brand and endorser	How well do coffee machines and X go together?		0.87		0.98		0.94
	To what extent does X's endorsement of the brand make sense to you?						
	How well do coffee machines fit with X's brand image?						
	X and coffee machines go very well together						
	Coffee machines and X's brand image have a strong fit						
Endorsement believability	How believable is X's endorsement for the brand?		0.82		0.88		0.77
	How credible is X's endorsement for the brand?						
Feeling of Elevation (Study 3)	I feel compassion after seeing the endorser X						0.94
	I feel inspired after seeing the endorser X						
	I feel awe after seeing the endorser X						
	I feel admiration after seeing the endorser X						
	I want to be more like the endorser X						
	The endorser X has shown me how to be a better person						
	I am going to try to follow the endorser X's example						
	I need to do more to help other people						
	I can learn a lot from the endorser X						
	The endorser X is my role model						

Table 1. Measurement items and reliabilities.

One week later, at Time 2, we invited the same participants to answer the same questions when the Mardi brand was matched with one of the three celebrity endorsers selected from the pre-test. After seeing the magazine advertisement with one celebrity endorser, participants were asked to answer questions on the enabling benefit ($\alpha = 0.91$), enticing benefit ($\alpha = 0.86$), and enriching benefit ($\alpha = 0.91$) of the brand "Mardi" as well as the enabling benefit ($\alpha = 0.96$), enticing benefit ($\alpha = 0.80$), and enriching benefit ($\alpha = 0.94$) of the celebrity endorsers adapting items from Park et al.'s (2013, 2016) measures. As part of our controls, we measured attitude toward endorser ($\alpha = 0.89$), coffee machine relevance ($r = 0.72$), fit between brand and endorser ($\alpha = 0.87$) from Till & Busler (2000) and endorsement believability ($r = 0.82$) on seven-point Likert scales (1 = strongly disagree, 7 = strongly agree).

Manipulation checks and potential confounds. In all four brand conditions, since no product benefit information was presented, the perceived levels of the product's functional, experiential, and symbolic benefits are the same, and the levels of each benefit are low (low enabling benefit condition, Menabling = 2.72, Menticing = 7.74, and Menriching = 7.60, $p < .05$; low enticing benefit condition, Menabling = 7.40, Menticing = 2.88, and Menriching = 7.63, $p < .05$; low enriching benefit condition, Menabling = 7.60, Menticing = 7.51, and Menriching = 2.94, $p < .05$).

Regarding the endorser conditions, since we pre-tested the celebrity seen as having high levels of

only one of the 3E benefits, respondents should perceive that the benefit we manipulate is higher than the other benefits. As expected, the results reveal that Whoopi Goldberg was regarded as higher in enriching than the other benefits (Menabling = 2.78, Menticing = 3.49, and Menriching = 5.76, $p < .05$); Lucy Liu, higher in enabling than the other benefits (Menabling = 5.63, Menticing = 3.23 and Menriching = 3.58, $p < .05$); and Ben Stiller, higher in enticing than the other benefits (Menabling = 2.68, Menticing = 5.96, and Menriching = 3.63, $p < .05$). Finally, the conditions did not differ in ways that might produce potential confounding effects.

A repeated-measures analysis of variance (ANOVA) was conducted to compare the effect of the four conditions (no endorser, Ben Stiller, Lucy Liu, and Whoopi Goldberg) on the respective level of a brand's three benefits between Times 1 and 2 when consumers had no information about the brand's benefits. Since we examine whether an endorser's high benefits transfer to the corresponding brand benefits, the dependent variables are the levels of enabling, enticing, or enriching brand benefits. Thus, we conducted a repeated-measures ANOVA three times for each dependent variable (see Fig. 1).

First, we examine the transfer effect of endorsers' enabling benefit on a brand's enabling benefit. A multivariate analysis tests the results for Time (within-subject factors) and the Time*Endorser interaction. There was a significant main effect of Time on the enabling benefit score, sphericity assumed ($F(1, 206) = 16.209$, $p = .000$), and a significant interaction between the effects of Time and Endorser on (enabling benefit) ($F(3, 206) = 9.502$, $p = .000$).

According to the tests of between-subject effects (four endorser conditions), the main effect of the treatment group on the enabling benefit score across time is statistically significant ($F(3, 206) = 4.091$, $p = .008$). The graph shows the average ratings of enabling benefits when the celebrity is "no endorser," Ben Stiller, Lucy Liu, and Whoopi Goldberg. Essentially, the ratings for the conditions of no endorser, Ben Stiller, and Whoopi Goldberg do not change over time. However, for Lucy Liu (with high enabling benefits), the ratings of enabling benefits for the brand increase significantly over time, indicating that the high enabling benefit Lucy provides has transferred to the brand.

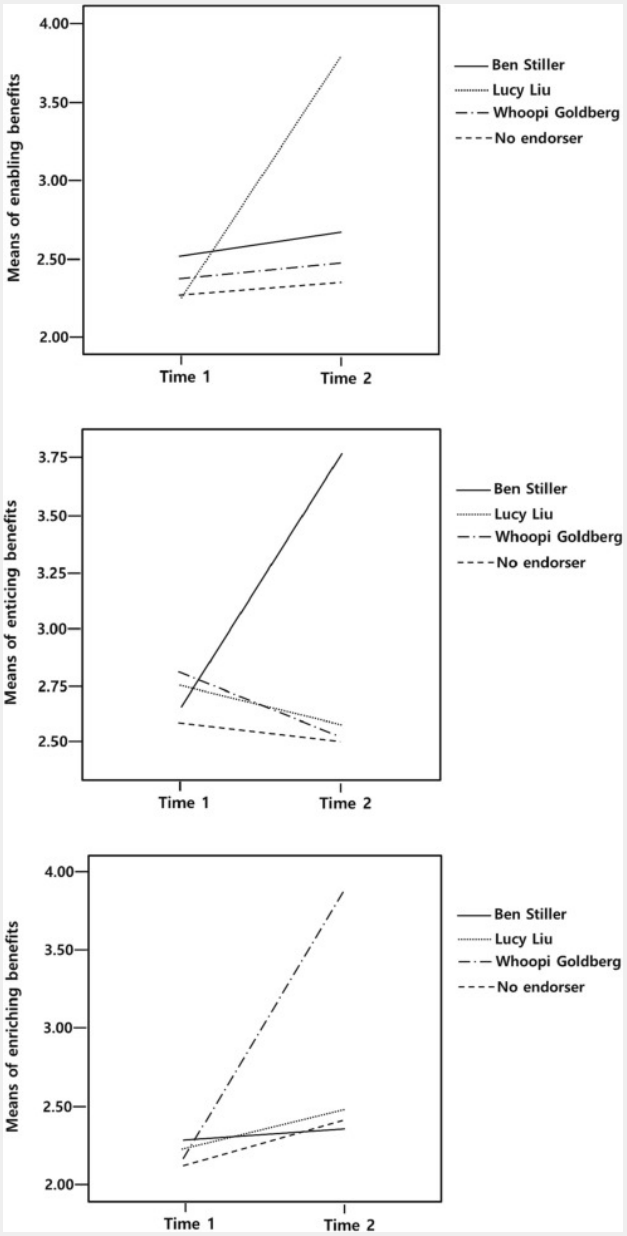

Fig. 1. The results of repeated-measures ANOVA

Next, we examine the transfer effect of endorsers' enticing benefit on the brand's enticing benefit. The main effect of Time on the enticing benefit score is not significant, sphericity assumed ($F(1, 206) = 1.618$, $p = .205$), and the interaction between the effects of Time and Endorser on the enticing benefit is statistically significant ($F(3, 206) = 9.123$, $p = .000$). According to the tests of between-subject effects (four endorser conditions), the main effect of the treatment group on the enticing benefit score across time is statistically significant ($F(3, 206) = 4.470$, $p = .005$). The graph shows that the ratings for the conditions of no endorser, Lucy Liu, and Whoopi Goldberg changed slightly over time.

However, for Ben Stiller, the ratings of brand enticing benefits increased significantly over time, indicating that the high enticing benefit Ben provides has transferred to the brand's enticing benefit.

Finally, we examine the transfer effect of endorsers' enriching benefit on the brand's enriching benefit. Time's main effect on the enriching benefit score is not significant, sphericity assumed ($F(1, 206) = 1.618$, $p = .205$), and the interaction between the effects of Time and the endorser on the enriching benefit is statistically significant ($F(3, 206) = 9.123$, $p = .000$). According to the tests of between-subject effects (four endorser conditions), the main effect of the treatment group on the enriching benefit score across time is statistically significant ($F(3, 206) = 4.470$, $p = .005$). The graph shows the ratings for no endorser, Ben Stiller, and Lucy Liu slightly changed over time. However, ratings of the enriching benefits for Whoopi Goldberg increased significantly over time, indicating that the high enriching benefit Whoopi provides has transferred to the brand's enriching benefit.

Thus, taken together, when respondents have no information about the brand's benefits, each of the endorser's strong benefits can successfully transfer to the corresponding benefit of the brand across the respective benefit conditions, thereby supporting H1.

In line with our theorizing, Study 1 demonstrates that the secondary brand associations affect evaluations of an unknown product when consumers cannot evaluate an endorsed brand by its benefits. Consumers are likely to accept the celebrity endorsers' benefits as the endorsed brand's benefit when the brand is new to them. Therefore, in case consumers are unaware of the specific benefits of the brand, celebrity endorsements can be an effective complementarity strategy to build all 3E brand benefits. However, one wonders about the effects of celebrity endorsement when the benefits of a brand are known to consumers. We thus conducted Study 2.

5.1 Study 2

Study 2 examines the transfer effects of celebrity endorsers' benefits to an endorsed brand when consumers possess knowledge about the brand's extant 3E benefits. Specifically, we focused on examining how each of the strong benefits of a celebrity endorser transfers to the endorsed brand with corresponding weak benefits, indicating the complementary conditions. We again used the fictitious coffee machine brand (Mardi) and the same set of celebrities from Study 1. However, Study 2 provided information about the 3E brand benefits, such as the product image, feature descriptions, and the brand name "Mardi" (see Fig. 2). By manipulating the degree of 3E benefits with the brand information, we created three brand conditions since the critical design factor in this experiment is to create the complementary condition. Hence, each brand condition has weakness in one benefit and strength in the other two benefits. As in Study 1, each condition is paired with three types of endorsers. Namely, we had a 3 (brand with only low enticing benefit, low enabling benefit, or low enriching benefit) × 3 (endorser with only high enticing benefit: Ben Stiller; high enabling benefit: Lucy Liu; or high in enriching benefit: Whoopi Goldberg) between-subjects design. Thus, one of the three brand conditions shows the complementary condition by pairing the brand with celebrity endorsers high in a particular benefit the brand does not have. For example, Ben Stiller, who is strong in the enticing benefit, is matched with the brand condition that shows weakness in that benefit. Among the nine conditions, we thus have three complementary conditions. Unless otherwise indicated, all Study 2 and its pre-test items were measured identically to Study 1.

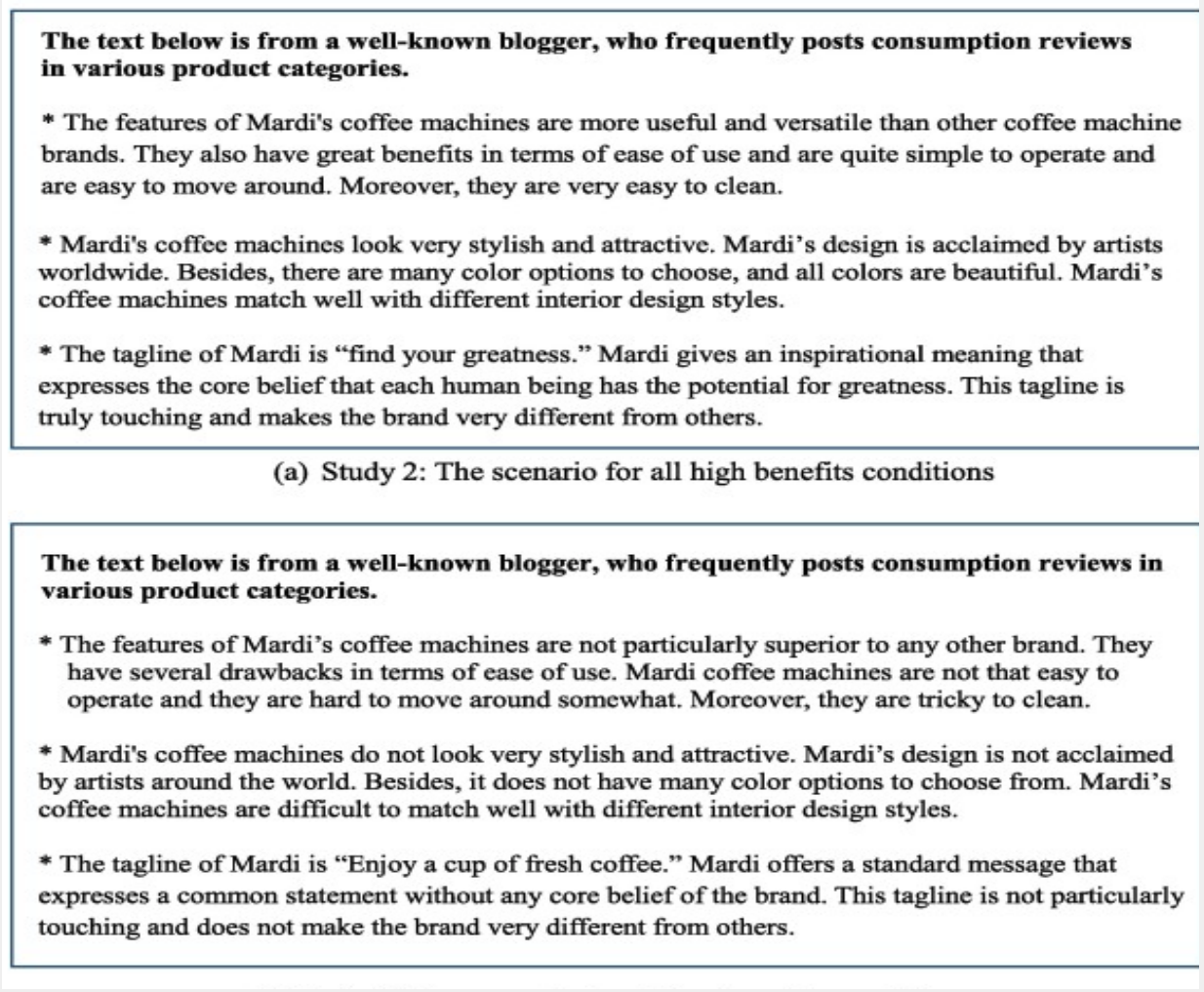

Fig. 2. Scenarios for all high and low benefits conditions.

After creating the stimulus for Mardi's three brand scenario conditions with manipulated 3E benefits, we conducted manipulation checks for each scenario to see if participants perceived the stimulus as intended. Regarding the brand with only low enabling benefits (high enticing and enriching benefits), pre-test (N = 32) results showed that participants observed that the brand has a low enabling benefit (M = 2.68), high enticing benefit (M = 7.79), and high enriching benefit (M = 7.61). Regarding the brand with only low enticing benefits (high enabling and enriching benefits), pre-test (N = 33) results showed that participants observed that the brand has a low enticing benefit (M = 2.94), high enabling benefit (M = 7.37), and high enriching benefit (M = 7.49). Regarding the brand with only low enriching benefits (with high enabling and enticing benefits), pre-test (N = 31) results showed that participants observed that the brand has a low enriching benefit (M = 2.90), high enticing benefit (M = 7.62), and high enabling benefit (M = 7.52). Thus, we confirmed that we successfully manipulated all three brand scenarios.

As part of a regular course requirement at their University, 239 students participated in Study 2. Respondents were randomly assigned to one of the nine conditions outlined in Fig. 1. As in Study 1, we conducted experiments at Times 1 and 2. At Time 1, participants were asked to read a blog review commentary for Mardi, which shows one of the three brand conditions, and answer questions on their perceived benefits of the brand on a nine-point Likert scale (1 = strongly disagree, 9 = strongly agree). Further, to control extraneous variables, respondents answered questions on brand excerpt believability, coffee machine relevance, and the current ownership of a coffee machine.

After one week (Time 2), we invited the same participants to read the blog review commentary about Mardi seen in Time 1. Importantly, the commentary featured one of the three celebrity

endorsers. Next, participants were asked to answer questions on the 3E benefits of the brand and endorsers on a nine-point Likert scale (1 = strongly disagree, 9 = strongly agree). As part of our controls, we measured respondents' attitude toward the endorser (α = 0.972), fit between the brand and endorser (α = 0.982), and endorsement believability (r = 0.884) on a nine-point Likert scale (1 = strongly disagree, 9 = strongly agree) at Time 2.

Manipulation checks and potential confounds. As indicated in Table 3, the manipulations were successful. The results further indicated that the conditions did not differ in ways that might produce potential confounders. Regarding the brand condition, since we manipulate only one benefit of the brand that is low among the 3E benefits, respondents should perceive that the only benefit we manipulate is lower than the other benefits. For example, the results show that in the low enabling brand condition, the enabling benefit was regarded as significantly lower than the enticing and enriching benefits (e.g., Menabling = 2.77, Menticing = 6.50, and Menriching = 5.91, $p < .05$). Regarding endorser conditions, as in Study 1, we used three endorsers with only one high benefit among the three benefits. All respondents successfully perceived that only the manipulated benefit is higher than the other benefits across all conditions. Table 2 reports detailed results and statistics of the other conditions.

N = 520	**Brand Low enabling benefit** (low enabling/high enticing/ high enriching)			**Brand Low enticing benefit** (low enticing/high enabling/ high enriching)			**Brand Low enriching benefit** (low enriching/high enticing/ high enabling)		
Manipulation checks (Time 1)	**Lucy Liu** (high enabling) (N = 26)	**Ben Stiller** (high enticing) (N = 25)	**Whoopi G** (high enriching) (N = 27)	**Lucy Liu** (high enabling) (N = 26)	**Ben Stiller** (high enticing) (N = 28)	**Whoopi G** (high enriching) (N = 26)	**Lucy Liu** (high enabling) (N = 25)	**Ben Stiller** (high enticing) (N = 27)	**Whoopi G** (high enriching) (N = 28)
Enabling brand benefits	2.53	3.09	2.71	5.87	6.60	6.20	6.56	6.03	6.26
Enticing brand benefits	6.50	6.39	6.60	2.58	2.75	2.84	5.73	6.81	6.41
Enriching brand benefits	6.24	5.90	5.61	6.00	5.93	6.16	3.19	2.91	2.98
Endorser enabling benefits	5.15	2.17	3.25	6.10	2.98	2.75	6.26	3.38	3.32
Endorser enticing benefits	3.07	5.31	3.60	3.93	6.08	2.71	3.22	5.60	3.06
Endorsers enriching benefits	2.81	2.51	6.00	3.40	3.17	6.30	2.84	3.76	5.57
Confounders									
Brand excerpt believability (Time 1)	6.19 [a]	6.12 [a]	5.87 [a]	6.53 [a]	6.39 [a]	5.96 [a]	6.14 [a]	6.25 [a]	6.10 [a]
Brand excerpt relevance (Time 1)	5.67 [a]	5.30 [a]	5.51 [a]	5.52 [a]	5.78 [a]	5.75 [a]	5.26 [a]	5.74 [a]	5.94 [a]
Current ownership (1 = yes) (Time 1)	0.88 [a]	0.84 [a]	0.88 [a]	0.92 [a]	0.89 [a]	0.92 [a]	0.96 [a]	0.88 [a]	0.92 [a]
Endorser attitude (Time 2)	5.46 [a]	5.46 [a]	5.41 [a]	5.45 [a]	4.80 [a]	5.46 [a]	4.52 [a]	5.10 [a]	5.90 [a]
Endorsement believability (Time 2)	5.40 [a]	5.72 [a]	5.16 [a]	5.61 [a]	5.30 [a]	5.40 [a]	5.56 [a]	4.87 [a]	5.57 [a]
Endorsement fit (Time 2)	6.03 [a]	5.30 [a]	5.53 [a]	5.26 [a]	5.27[a]	5.72 [a]	6.07 [a]	5.34 [a]	5.48 [a]
Dependent variables **(Time 2)**									
Enabling brand benefits	2.62	3.07	2.97	6.10	4.54	6.30	6.12	4.61	6.29
Enticing brand benefits	6.72	6.34	6.67	2.95	2.66	3.04	7.11	7.05	6.65
Enriching brand benefits	6.10	3.83	5.59	6.33	4.63	6.25	3.07	2.48	6.20

Table 2. Manipulation checks and hypotheses testing.

In Study 2, as in Study 1, a repeated-measures two-way ANOVA was conducted to compare the effect of endorser type on the level of each of the three benefits of the brand between Times 1 and 2 under three brand conditions: low enabling benefit, enticing benefit, and enriching benefit (see Fig. 3).

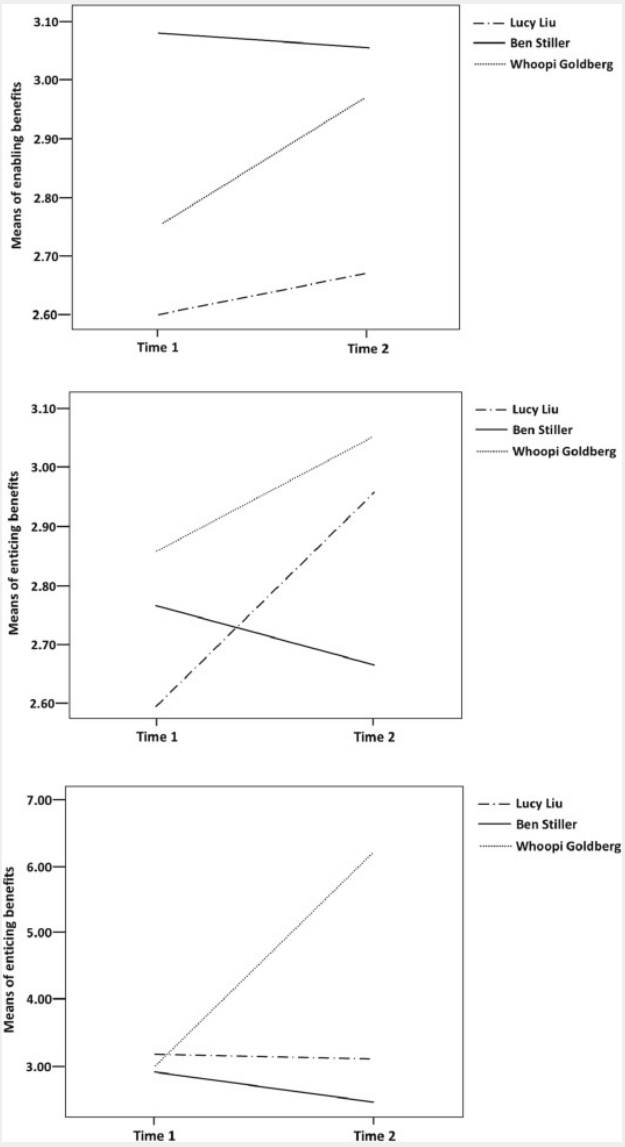

Fig. 3. The results of repeated-measures ANOVA (Study 2).

First, we examine the transfer effect of endorsers' enabling benefit on a brand's enabling benefit for brands with low enabling benefit. A multivariate analysis tests the results for Time (within-subject factors) and the time*endorser interaction. There was no significant main effect of Time on the enabling benefit score, sphericity assumed ($F(1, 75) = 0.810$, $p = .371$); there was no significant interaction between the effects of time and endorser on the enabling benefit ($F(2, 75) = 0.483$, $p = .619$). According to the tests of between-subject effects (three endorser conditions), the main effect of the type of endorsers on the ratings of enabling benefit across time is not statistically significant ($F(2, 75) = 598$, $p = .553$). When the celebrity endorser is Ben Stiller, Lucy Liu, or Whoopi Goldberg, the ratings in all celebrity conditions do not change over time. Importantly, although Lucy Liu has a high enabling benefit, her benefit did not transfer to the brand's benefit when respondents knew the brand has a low enabling benefit. Thus, for brands respondents are known to, an endorser's enabling benefit does not complement and help strengthen a brand with corresponding low benefits, thereby supporting H2.

Next, we examine the transfer effect of endorsers' enticing benefit on the brand's corresponding benefit for the brand with a low enticing benefit. A multivariate analysis tests the results for Time (the within-subject factors) and the time*endorser interaction. There was no significant main effect of Time on the enticing benefit score, sphericity assumed ($F(1, 77) = 1.755$, $p = .189$); there was a significant interaction between the effects of Time and Endorser on enabling benefit, $F(2, 77) = 1.348$, $p = .266$). According to the tests of between-subject effects (four endorser conditions), the main effect of the treatment group on the enticing benefit score across time is not statistically significant ($F(2, 77) = 0.166$, $p = .847$). The ratings regarding all celebrity endorsers do not significantly change over time. Given that Ben Stiller has low enticing benefits, enticing benefits of the brand do not significantly change. In support of H2, an endorser's enticing benefit does not complement and help strengthen a brand benefit that is low in the corresponding benefits when the brand's benefits are known to consumers.

Finally, we examine the transfer effect of endorsers' enriching benefit on a brand's benefit for brands with low enriching benefit. A multivariate analysis tests the results for Time (the within-subject factors) and the time*endorser interaction. There was no significant main effect of Time on the enriching benefit score, sphericity assumed ($F(1, 77) = 17.013$, $p = .000$); there was a significant interaction between the effects of Time and Endorser on (enriching benefit) ($F(2, 77) = 30.442$, $p = .000$). According to the tests of between-subject effects (three endorser conditions), the main effect of the treatment group on the enriching benefit score across time is not statistically significant, $F(2, 77) = 16.313$, $p = .000$. Specifically, regarding Ben Stiller

and Lucy Liu, there was no significant difference in the level of Mardi's enriching benefits (t (27) = 1.410, p = .170; (t(25) = 0.317, p = .714) at Times 1 and 2, respectively. However, as we theorized, regarding Whoopi Goldberg, who embodies a high enriching benefit, there was a significant difference in Mardi's level of corresponding benefit at Times 1 (M = 2.985, SD = 1.610) and 2 (M = 6.200, SD = 2.074); (t(27) = 7.142, p = .000). The enriching benefit of the brand has been significantly increased, even though participants were previously informed about the brand's weak enriching Together, these results support H2.

5.2 Study 3

In Study 3, we employed a set of Chinese celebrities and created a fictitious smartphone brand, "Lumigon." Further, to alleviate any gender effect, we employed celebrities of the same gender. All three endorsers were male. We chose a smartphone brand instead of the coffee machine brand in Studies 1 and 2 for the following reasons. First, we intended to select a stimulus from a product category other than home appliances to further validate the influence of the benefits of celebrity endorsers on brands. Second, celebrity endorsement is pervasive in consumer electronics product settings.

To directly compare the transfer effects of an endorser's benefit for unknown and well-known brand cases, we created two brand conditions: the conditions with and without information on brand benefits. Importantly, we focused on and created complementary conditions regarding well-known brand conditions. All conditions in the unknown brand case are designed to show complementary situations.

Study 3 was a 3 (endorser with only high enabling benefit, high enticing benefit, or high enriching benefit) × 2 (well-known or unknown brand benefits) experiment. Unlike Studies 1 and 2, which employed celebrity endorsers of different genders and occupations, Study 3 employed three male athletes: Fangyu Zhu, a professional basketball player, for the celebrity with only high enabling benefit; Zetao Ning, an attractive swimming athlete, for only high enticing benefit; and Ming Yao, a former basketball player and current philanthropist, for only high enriching benefit. For manipulating the well-known brand condition, we used the same procedure as in Study 2. In the unknown brand condition, the experiment scenario solely shows a brand name endorsed by a celebrity. In the well-known brand condition, the experiment scenario includes the blog commentary about the brand and descriptions of the three benefits of the brand which complement the benefits of the endorser. For example, as shown in Table 4a, the well-known brand case of Fangyu Zhu, with a very high enabling benefit, matches Lumigon, which has a very low enabling benefit. Therefore, Study 3 has six experimental conditions.

Eighty-two participants (73.2 % female, average age of 23.42 years) were recruited from a university in China. The participants were randomly assigned to evaluate one of the following three celebrities, Fangyu Zhu (N = 24), Zetao Ning (N = 29), and Ming Yao (N = 29). The three endorsers were selected because they are all celebrity athletes with high popularity among Chinese consumers, thereby ruling out potential confounding factors such as celebrity expertise and familiarity. In the pre-test, the participants were asked to evaluate their enabling, enticing, and enriching benefits.

238 participants (63.0 % female, average age of 29.38) were recruited online to participate in the study at a university in China and randomly assigned to one of the six conditions. The experiments were conducted at Times 1 and 2. At Time 1, participants were instructed to read a blog commentary of a smartphone brand named Lumigon and evaluate the 3E benefits of the brand (outcome variable) and their relevance with the smartphone product category (control variable). After one week, at Time 2, the same participants were shown a blog commentary with a celebrity endorser. After reading the blog commentary, participants were evaluated on their perceptions of the 3E benefits of the endorser and the brand and three control variables (i.e., attitude toward an endorser, fit with the brand, and endorsement believability). All constructs, including the feeling of elevation, were measured using the same items and nine-point Likert scale as Study 2.

Manipulation checks. We successfully manipulated the levels of endorsers' benefits. For the manipulation of celebrity endorsers, the results indicate that Fangyu Zhu was perceived to have

higher enabling (Menabling = 6.43) than enticing (Menticing = 5.89, $p < 0.001$) and enriching benefits (Menriching = 5.92, $p < 0.001$); Zetao Ning, higher enticing (Menticing = 6.90) than enabling (Menabling = 5.80, $p < 0.001$) and enriching benefits (Menriching = 6.32, $p < 0.001$); and Ming Yao, higher enriching (Menriching = 6.89) than enabling (Menabling = 5.91, $p < 0.001$) and enticing benefits (Menabling = 6.15, $p < 0.001$). For the manipulation of brand benefits, relative to the condition with no brand benefit information, participants perceived the brand we manipulated as low among the three benefits as having the lower benefit. Specifically, relative to the condition without brand benefit information, (1) participants perceived the brand as having a significant lower enabling benefit in the condition with brand benefit information (Mwithout enabling benefit = 6.31, Mwith enabling benefit = 3.91, $p < 0.001$); (2) participants considered the brand as having a lower enticing benefit in the condition with brand benefit information (Mwithout enticing benefit = 5.69, Mwith enticing benefit = 5.09, $p < 0.05$); (3) the participants perceived the brand as having a lower enriching benefit in the condition with brand benefit information (Mwithout enriching benefit = 6.16, Mwith enriching benefit = 5.54, $p < 0.05$).

6. Marketing Plan

Consistent with the findings in Studies 1 and 2, Study 3 shows that only the enriching benefits of the endorser complemented the weak corresponding benefits of the endorsed brand when respondents already have 3E benefit information on the endorsed brands. In addition, the endorser's enabling, enticing, and enriching benefits are transferred to the endorsed brands when respondents have no prior 3E benefit information on the endorsed brands. Critically, Study 3 shows that the celebrity endorser's enriching benefits are transferred to the endorsed brand through elevation.

The current findings contribute to the growing literature on celebrity endorsement marketing strategies. Specifically, the study suggests a new perspective of celebrity endorsement regarding the complementarity strategy to build desired brand associations by leveraging secondary associations. That is, this study extends previous research, which largely focuses on the commonality strategy of similarity or matching between a brand and its endorser (Albert et al., 2017, Kamins, 1990, Lee and Thorson, 2008, Till and Busler, 2000). As previous studies have shown, high levels of congruency between a celebrity endorser and an endorsed brand make celebrity endorsement effective. However, the current findings suggest that the complementarity approach using a celebrity with no matching benefits with the focal brand is also an effective celebrity endorsement strategy and, thus, extend the literature on celebrity endorsement and leveraging secondary association theory.

Moreover, we examined the various benefits of brands by drawing on 3E brand benefits to show when the benefits of a celebrity endorser can effectively complement different weak brand benefits. It is important to consider the diverse benefits of brands for celebrity endorsements since brand benefits by their nature (intrinsic or extrinsic) are perceived differently by customers, requiring different complementary strategies based on the level of consumer knowledge about an endorsed brand. To the best of our knowledge, no prior studies have applied 3E brand benefits to the context of celebrity endorsement.

Further, the findings emphasize the important role of a celebrity's enriching benefits in celebrity endorsements because, given the nature of extrinsic brand benefits, only enriching benefits can get transferred to a brand regardless of the level of consumer knowledge of the brand. The results suggest that the significance of the enriching benefits of a celebrity endorser and the transfer mechanism needs further study. In this regard, we revealed how a celebrity endorser's enriching benefits complement the low enriching benefits of an endorsed brand through a feeling of elevation, regardless of the level of consumer knowledge about the brand. Thus, as one of the first that studies elevation in the context of business study, the current findings on elevation may shed light on a new research stream of celebrity endorsement; namely, celebrities may act as a source of elevation for the customers of certain brands (e.g., consider Michael Jordan and Nike or Lindsey Vonn and Red Bull, George Clooney and Nescafe, etc.). Admiration, which is also part of the other-praising emotions, has been studied in the context of business study. Thus, further studies on elevation and its role in the context of celebrity endorsement

is richly deserving. In addition to theoretical contributions, the current findings provide critical insights for marketing practitioners.

The study findings must be viewed in light of their limitations, pointing to promising avenues for future research. First, we could replicate our findings with consumers across different countries. However, we did not study consumers' responses to different brands, such as B2B products, non-profit products, experiential products, and luxury products. Specifically, the levels of product involvement may moderate the effect of celebrities' benefits on brands' benefits. Particularly, the effects of enriching benefits may be influenced by consumers' product category and brand-related involvement. For example, the purchase intention or brand attitude toward high-involvement products such as automobiles, electronic gadgets, and luxury fashion items or even tourism and adventure trips of exploration (say to Spitzbergen or the world's northernmost inhabited areas, visiting the town of Maotai in China's Guizhou province, or a remote, peaceful Alpine chalet) may be affected by inspiring or symbolic images. Thus, future research testing the observed effects across different contexts (e.g., high vs. low involvement) is richly deserving. Second, we tested elevation as a mediation of benefit transfer from a celebrity with strong enriching benefits to an endorsed brand. Considering admiration is also part of the same other-praising family coming from observing non-moral excellence, future research may explore how elevation interacts with admiration for building stronger consumer-brand relationships in the context of celebrity endorsements. Third, we conducted experiments and collected data in lab settings to establish causality and test the proposed effects. We encourage future work to conduct field studies to strengthen confidence in the generalizability of the current findings.

Moreover, although we study a brand's 3E benefits, additional benefits may exist that endorsers may transfer to a brand. We encourage future research to explore these additional benefits. Fourth, brand endorsers are increasingly employed for digital brands or in a digital context, such as online gaming, shopping, search and social media. Thus, future research may extend the current research to include digital branding contexts such as artificial intelligence (AI) chatbot agents such as OpenAI's ChatGPT, Google's Bard or Microsoft's Bing or other virtual salespeople, which may well serve as a brand's endorser in the years to come.

7. Finance and Fundraising

Given the current findings on the efficacy of employing the complementarity approach in celebrity endorsements, it is imperative for managers to consider a diverse range of strategies rather than solely relying on the prevalent commonality approach. Complementarity branding strategies are crucial in conveying the intended message to consumers (Keller & Swaminathan, 2020). Nonetheless, Keller and Swaminathan (2020) posits that the deployment of meticulously crafted strategies is indispensable to mitigate potential consumer confusion or skepticism. The current findings are hence of critical import and indicate that the successful implementation of a complementarity strategy in celebrity endorsement is contingent upon the consumers' knowledge of the endorsed brands. In instances where consumers are unaware of a product's benefits (e.g., a novel product), they are inclined to ascribe the advantages associated with celebrity endorsers to the endorsed brands. As such, the utilization of a celebrity endorser possessing the desired attributes for the endorsed brand is likely to yield effective results. This approach would also prove beneficial for existing products with limited popularity, as consumers may not possess a comprehensive understanding of the brand's advantages.

Hence, when consumers are aware that the endorsed products do not possess significant enabling or enticing benefits (intrinsic benefits), they fail to perceive the celebrity endorsers' enabling or enticing benefits as complementary to the endorsed product. The current findings, therefore, suggest that businesses should avoid utilizing celebrity endorsers with prominent enabling or enticing benefits to amplify these benefits when the consumers are cognizant of the endorsed product's deficiency in these areas, as this approach proves to be an ineffective endorsement strategy. In order to bolster the weak enabling or enticing benefits, it would be more advantageous for the brand to enhance these benefits within the product itself before capitalizing on a celebrity endorser's corresponding benefits. Once the product is perceived to possess robust

enabling or enticing benefits, employing commonality endorsement strategies that exhibit a high congruence between the benefits of a product and an endorser would effectively strengthen these benefits further. Alternatively, based on our findings, the brand could consider selecting a celebrity endorser with exceptional enriching benefits, enabling the endorsed product to augment the enriching benefits for complementarity endorsement strategies, while simultaneously fortifying the enabling and enticing benefits within the product itself.

Considering that the enriching benefits associated with a celebrity can be conferred upon both established and unfamiliar endorsed brands, it is crucial for marketing professionals to judiciously employ celebrity endorsements possessing substantial enriching benefits. Prior research also advocates for the augmentation of a brand's enriching benefits in order to cultivate customer loyalty behaviors (Park et al., 2016). Park and colleagues posit that the enriching benefits of a brand wield greater influence in fostering customer loyalty compared to enabling and enticing benefits, as the former can intensify the sense of esteem towards the brand (Park et al., 2013, Park et al., 2016). Thus, practitioners can amplify a brand's enriching benefits through a celebrity endorsement characterized by pronounced enriching benefits, generating a feeling of elevation for the celebrity irrespective of the brand benefits' familiarity to consumers. It is essential for practitioners to contemplate strategies for elevating the sentiment of admiration derived from a celebrity endorser with high enriching benefits. In this regard, when a celebrity possessing significant enriching benefits endorses a product, it would be advisable to emphasize the celebrity by highlighting inspirational stories about the celebrity rather than concentrating on the product itself, in order to bolster the endorsed product's enriching benefits.

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