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How Technology is Changing Retail☆

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Abstract

Retailing is undergoing a remarkable transformation brought by recent advances in technology. In this paper, we provide a deep discussion of and look ahead on how technology is changing retail, starting with a classification of technologies that impact retailing, in particular, in the COVID-19 and beyond world. We discuss different theoretical frameworks or lenses to better understand the role of technology in retailing. We identify and elaborate on the drivers and outcomes of technology adoption by shoppers, retailers, employees, and suppliers. We speculate on future retail scenarios and outline future research avenues on technology and retailing. We close by concluding that technology is not only reshaping retailing, but also allowing retailing to pivot in the face of new and unforeseen circumstances.

Keywords: Innovation; Shopping; Customer; Supplier; Sharing economy; Smart distancing

Introduction

Recent advances in technology have reshaped and continue to reshape many industries. Retailing is no exception. In recent times, technological advances have accelerated dramatic shifts and caused significant disruptions in the retail landscape. For example, with technology-driven innovations ranging from one-click ordering to personalized recommendation to smart speakers to anticipatory shipping, Amazon has redefined shopping and displaced many brick-and-mortar retailers (Nichols 2018; Shankar 2019; Xiao and Benbasat 2007). Many of these technologies are powered by artificial intelligence (AI), which is reshaping retailing in a big way (Shankar 2018). "AI refers to programs, algorithms, systems or machines that demonstrate intelligence. More generally, it is used to denote a set of tools that can enhance the intelligence of a product, service, or solution" (Shankar 2018, p. vi). Applications of AI in retailing include personalization and recommendation systems, sales/customer relationship management, customer service management, supply chain optimization, inventory management, and store task creation.

The role of technologies in retailing has taken a dramatic leap following the outbreak of the COVID-19 pandemic. As a result of the shelter-in-place and lockdowns aimed at containing the spread of coronavirus, many brick and mortar retailers have been forced to close down physical stores and move more rapidly toward technology-based solutions such as online ordering and fulfillment, click and collect, and robot-assisted operations.

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The dramatic week-to-week or day-to-day changes in shopping trends during the pandemic's outbreak mean that those with instant access to data would be better informed and make better investments than those using less current data. Mobile global positioning systems (GPS) tracking used for store traffic updates is just one way technology is helping brands and retailers keep up with wild shifts in shopper behavior during this extraordinary outbreak (Doolittle 2020).

Given the pace at which technology is changing retailing, researchers and practitioners in retailing seek a systematic understanding of the nature and extent of these impacts. While much research has examined how technologies such as point-of-sale, automated teller machine (ATM), and the Internet have changed retailing (e.g., Varadarajan et al. 2010), not much is known about the impacts of emerging technologies such as micro-cloud computing, new robotics, fifth generation (5G) telecommunication, the Internet of Things (IoT), virtual reality (VR), augmented reality (AR), and mixed reality (MR) on retailing.

Cloud computing, the practice of using a network of remote servers to store, process, and manage data, has been widely adopted by both retailers and supply chain members. Cloud computing is surging in popularity because it is becoming cheaper, more scalable, and more secure than before, allowing retailers of all sizes to use it. Micro-cloud computing is a special cloud computing technology that allows customers to be closer to their users and other existing infrastructure at a smaller scale without compromising performance and without being tied to a large public cloud. A micro-cloud located geographically at the store/location of retail will support resource-intensive and interactive mobile applications by providing the computing and data resources to mobile devices with lower latency, while not putting an economic strain on the enterprise. These micro-clouds will also help manage the ever increasing "data ocean" created within a retail location/environment. For example, stores and consumer manufacturers can offer personalized digital coupons on items that move slowly at a specific location using the data on local micro-cloud with little or no latency (lag). Such a practice can lead to increased sales and consumer loyalty.

As many shoppers and retailers move a large portion of their business online during the COVID-19 outbreak either by choice or due to regulation, having a contemporary and scalable cloud infrastructure in place is essential for retailers to serve their customers and capture sales. It also aids business continuity as formerly office based employees can continue their duties from remote locations with minimal disruption.

Robotics as a broad technology has existed for several decades. Relatively newer innovations such as shopbots, home robots, store robots, delivery drones, and warehouse robots have accelerated robotics' impact on retailing. Until the onslaught of COVID-19, the adoption of technologies such as in-store robots and delivery drones was limited. However, the need for less human contact and social distancing has turned this situation on its head. Robotics is likely to thrive in the COVID-19 and beyond world, substantially boosting retail automation.

5G refers to the fifth generation of wireless telecommunication technology that supports cellular data, voice, and video networks. It involves superfast transmission of signals, enabling many instantaneous, stable, and real time interactive digital and in-store shopping applications, including those involving other technologies such as IoT, VR, AR, and MR with AI at the edge. 5G can help retailers with several use cases. 5G can reduce the power consumption of in-store IoT devices, allowing retailers to access technology like smart labels and other retail enhancing sensors. It opens several use cases in the area of personalized signage based on proximity of the customer to the sign itself. It also has long-term potential for less expensive and timelier ways of tracking product within the supply chain.

The IoT is "a system of uniquely identifiable and connected constituents (termed "Internet-connected constituents") capable of virtual representation and virtual accessibility, leading to an Internet-like structure for remote locating, sensing, and/or operating the constituents with real-time data/information flows between them" (Ng and Wakenshaw 2017, p. 6). VR is a technology that offers an immersive experience where everything viewed is artificial. VR simulates the environment, shutting out the real world through a wearable device (typically a headset) to provide an immersive 3D environment (e.g., virtual video games). AR creates an add-on and interactive experience of a real-world environment through computer-generated displays, creating interactive, vivid and rich experiences (Yim, Chu, and Sauer 2017). MR combines AR and VR to produce visual environments in which physical and digital elements interact in real time (Milgram and Kishino 1994). Many of the technologies are powered by artificial intelligence (AI). The integration of AI into these emerging technologies adds another layer of change to the retail ecosystem. There is a dearth of deep analyses and frameworks that enable a better understanding of the impact of these technologies on retailing.

In this paper, we seek to close this gap in understanding of technologies' impact on retailing. In the next section, we begin by presenting a classification of technologies that impact retailing. We then discuss different theoretical frameworks or lenses to better understand the role of technology in retailing. We follow it up by identifying and elaborating on the drivers and outcomes of technology adoption by shoppers, employees, suppliers, and retailers.[1] In the subsequent section, we speculate on future retail scenarios and outline future research avenues on technology and retailing. We close with our conclusions on how technology is reshaping retailing.

Our paper makes important contributions over relevant existing research. Grewal, Noble et al. (2020) propose a 2×2 framework for classifying innovative and futuristic in-store technologies based on their level of convenience and social presence for the consumer. Davenport et al. (2020) advance a multidimensional framework for understanding the impact of AI, and Shankar (2018) and Grewal, Haenlein et al. (2020) and Grewal, Kroschke et al. (2020) offers insights into how AI is transforming retailing. In contrast to these studies, we offer a classification, an organizing framework, antecedents and outcomes for how tech-

[1] For expositional ease, we use the terms, shopper, consumer, and customer, interchangeably throughout the paper.

Table 1
A comparison of our work against selected prior research.

Paper	Focus	Takeaways from framework
Shankar (2018)	Artificial intelligence (AI) in retailing	AI is significantly reshaping retailing. It will have less impact in the short-term than anticipated, but more effect in the long-term than imagined.
Davenport et al. (2020)	AI and marketing	AI will likely substantially change both marketing strategies and customer behaviors. A framework based on intelligence level, task type, and AI embedded in a robot explains AI's impact on marketing strategies, customer behaviors, and policy on privacy, bias and ethics. AI will be more effective if it augments and not replace humans.
Grewal, Hulland et al. (2020)	Technology and marketing	More research is needed to establish both the fundamental effects of technologies (e.g., AI, robotics, IoT, augmented technology) and the underlying processes that explain the consequences on the behavior of customers and employees.
Grewal, Noble et al. (2020)	In-store technology	A 2 × 2 matrix of innovative and futuristic technologies based on convenience level and consumer social presence can explain the effects of in-store technology on sales. Convenience and social presence can trigger vividness by enhancing consumer involvement, imagery, and elaboration, which ultimately leads to enhanced sales. The effect is moderated by consumer traits, product/service dimensions, mental models and social networks.
Hoyer et al. (2020)	Emerging technologies and customer experience	A typology based on task type (repetitive vs. non-repetitive) and shopper stage (cognitive vs. behavioral) can explain new technologies powered by AI. A framework for understanding the role of new technologies on the customer/shopper journey is rooted in cognitive vs. sensory vs. emotional classification. The impact and implications of these technologies can be understood by examining each broad stage of the shopping journey (pre-transaction, transaction, and post-transaction).
Grewal, Haenlein et al. (2020) and Grewal, Kroschke et al. (2020)	AI and retailing	A framework based on the specificity of the AI application, salience of privacy and ethical concerns, and customer culture can help understand the impact of AI on retailing. In retailing, non customer-facing AI applications may be associated with substantial value and are likely to be implemented faster.
Our paper (2020)	Technology and retailing	The impact of technology on retailing can be better understood by a framework delineating the drivers and outcomes of technology adoption on shoppers, retailers, and employees. The future scenarios of technology's impact on retailing include smart distancing, retailer disintermediation, sharing/gig economy, hybrid bundles, and new retailer types.

nology is changing retailing. Hoyer et al. (2020) propose and discuss a new framework for understanding the effect of technology on the customer experience. While Grewal, Noble et al. (2020) focus on in-store technology, we study all technologies in general. Unlike Davenport et al. (2020), Grewal, Haenlein et al. (2020) and Grewal, Kroschke et al. (2020) and Shankar (2018) who focus on AI, we examine different technologies, only some of which may be driven by AI. Finally, while Hoyer et al. (2020) focus on customer experience, we cover the impact of technology on different stakeholders, including retailers and employees. A comparison of our work over these related work appears in Table 1.

Classification of Technologies Impacting Retailing

To bind the scope of this article, it is important to have a working definition of technology. Many definitions of technology exist. One abstraction is that technology is the application of scientific knowledge for practical purposes. Another abstraction rooted in economics is that technology is a process or tool that helps us produce outputs faster, better, and cheaper. Our operationalization of technology is focused on information and communication technologies, which are systems used for storing, retrieving, processing, and sending information. These systems require both hardware and software components.

As outlined earlier, many emerging technologies are influencing retailing and will likely continue to affect it in the future. These technological influences will be on both the demand and the supply sides. Technology also influences delivery, which connects the two sides with supply fulfilling the demand.

On the demand side, these technologies create digitized services such as AI-enabled consumer choice assistance, recommendations, and ecommerce. They also help retailers build delivery capabilities such as buy online and pick up offline and develop support and payment competencies through automated customer service, digital payment service, and telemedicine service. Increasingly, these technologies are delivered through mobile devices and platforms that leverage the growing use of mobile technology by shoppers for purchase research, purchase execution, and order tracking. Shoppers spend more time on the mobile than on other media. At three hours and 43 min a day, the average time spent by U.S. individuals on mobile overtook that on TV during 2019 (eMarketer 2019).

From the supply chain standpoint, warehouse robots, scan drones, and scan robots are assisting humans. In some cases, these technologies are replacing humans, causing a wholesale repurposing of the roles they play within the supply chain. Some of the demand induced digitized services are also creating a strain on the delivery side of the supply chain due to the growing instant gratification needs of shoppers.

Delivery technologies such as those used by Amazon's two-day and same day delivery services better connect shoppers with retailers, facilitating choice, simplifying ordering, and making returns easy. For example, Amazon has partnered with Kohl's to accept at Kohl's locations, customer returns of purchases made through Amazon. Kohl's system links with Amazon's order and delivery system efficiently to consolidate the return shipping of Amazon orders. Mobile and other emerging technologies are moving the shelf edge and service desk closer to the shopper. To meet demand, delivery technologies such as flying autonomous vehicles (drones), autonomous light cargo delivery vehicles, and bots (e.g., Starship Technologies) are becoming popular.

In the retailing context, we can categorize these technologies by stakeholder type as follows.

Customer-Facing/Shopper-Facing Technologies

These technologies are used by customers/shoppers and facilitated by retailers to enhance customer engagement with products, services, or brands. Examples include mobile devices, wearables, smart speakers, AR, VR, and MR systems, chatbots, smart mirrors, and payment technologies. Shopper marketing research and practice suggest that such technologies have an important role to play along a shopper's shopping journey (Lee et al. 2018; Shankar 2014; Shankar et al. 2016). Emerging technologies such as AR (Hilken et al. 2017; Yim, Chu, and Sauer 2017), VR (Beck and Crié 2018), IoT (Ng and Wakenshaw 2017; Scholz and Duffy 2018), mobile apps (Narang and Shankar 2019; Shi and Kalyanam 2018), and facial recognition technology (Kodra et al. 2013) may have both intended and unintended consequences on the customer relationship and the future of retailing. Retailer facilitation and value creation together with shopper adoption are critical to the success of these shopper-facing technologies (Inman and Nikolova 2017).

Many of the shopper-facing technologies are in-store technologies, several of which have been implemented by retailers (Grewal, Noble et al. 2020). Some examples that enhance shopper's convenience within the stores are: Amazon Go's automated checkout, Kroger's digital price tag, Zara's self-checkout, Ted Baker's interactive window, and Target's mobile wallet. In-store mobile advertising can be effective if the primary value drivers, namely, location, personalization, and price-promotions are suitably leveraged in that order (Bues et al. 2017).

Employee-Facing Technologies

These technologies are primarily used by employees to carry out their activities or tasks. However, these technologies also impact employee-consumer relationships by providing new tools for interaction in a live environment. Examples include mobile devices, hand held scanners, price scanners, IoT, RFID, and AR technologies, and smart mirrors. Some technologies such as smart mirrors can impact customers and employees simultaneously. Therefore, it might be useful to distinguish between technologies that require customers and employees to co-produce synchronously versus asynchronously. As such, synchronous technologies that require both customers and employees to co-produce can be considered more complex because they have more moving parts than asynchronous technologies.

Work from home (WFH) technologies are growing rapidly during COVID-19 and beyond. More retail employees are working from home to facilitate retail ordering and delivery. The WFH technologies include adaptive WiFi, video-calling services, instant communication tools, project management platforms, and digital assistants. Adaptive WiFi optimally allocates bandwidth based on the location and time of usage. Vide-calling services include Zoom, Skype and Google Hangouts that facilitates employees keeping in touch with one another. Instant chat tools like Slack, Telegram and Quip allow employees to simulate in-office communication using the Internet. Project management platforms like Asana and Trello enable employees to track and monitor projects remotely. Digital assistants like Amazon Alexa, Google Assistant, and Apple Siri enhance employee productivity by acting as electronic personal assistants.

Supplier-Facing Technologies

These technologies are used by manufacturers who supply to retailers. Examples include IoT, RFID, payment, and blockchain technologies. Blockchain technology is an open, distributed, verifiable, and permanent ledger that can potentially improve supplier-retailer contracts, inventory control, and supply chain efficiency.

Another way to classify technologies in the retailing context is based on whether they are related to information or not. Accordingly, they can be classified as information technology (IT) versus non-IT. As outlined earlier, our primary focus is on information related technologies. Many of the IT based technologies are also communication technologies. IT based technologies have a large ecosystem and new technologies may have to fit into this system. Non-IT based technologies include healthcare technologies that are biotechnology based and are relevant for pharmacies, retail clinics, health clubs, and fitness centers. Some Asian malls are using non-IT based technologies to combat COVID-19 and make shopping safe. For example, Hong Kong's New World Development mall K11 MUSEA uses minimum efficiency reporting value (MERV) 14 and activated carbon filters to create air quality comparable to hospitals; Singapore's Northpoint City shopping mall uses autonomous mobile robots to disinfect surfaces with ultraviolet light capable of destroying all but one per cent of bacteria (Lung 2020).

Sometimes, retailers can combine IT and non-IT-based technologies to solve business problems. An example is sustainability and wastage reduction that is important for retailers, in particular, fashion retailers such as H&M and Zara in Europe. Fast fashion creates multiple prototypes, colors, and samples

that do not make it market. In addition, apparel is seasonal and unsold items need to be disposed. Fast fashion retailers can use advances in chemical technologies to create minimal wastage. In addition, they can use 3D and augmented reality to reduce time to production and operate the prototyping and sampling phases.

Technologies can also be classified by domain or source of origin. To describe technologies, researchers use classifications that may be specific to a domain or span multiple domains. Some retail technologies may span different types of retail categories, while others may be specific to a category. Setia, Deng, and Jena (2017) classify and examine information technology (IT) competencies as internal and external across the demand and the supply sides. Some technologies may be developed in-house, while others outsourced. Similarly, technologies may be conceptualized as IT resources based on their usage as outside-in, spanning, or inside-out (Wade and Hulland 2004). Some suppliers can push new technologies for retailers to adopt. In some cases, retailers can pull or push suppliers to adopt new technologies.

Classified differently, technologies may be incremental or radical in newness. For example, the transition from 4G to 5G telecommunication technology can be viewed as incremental, whereas the movement from wired toward wireless power technology could be considered as radical. This classification has potentially important implications for retailers. Radical technologies might require much greater adoption efforts and change management especially for retailers who may have to deploy these technologies in multiple dispersed locations.

Another way to categorize technology is based on how it changes the existing retailing landscape. Some technologies facilitate business, while others disrupt business. For example, Applepay operates on top of the existing payment ecosystem and offers greater convenience to shoppers. Thus, it can be viewed as a facilitating technology. In contrast, blockchain technology, exemplified by Facebook's Libra, could potentially upend the payment ecosystem by turning the current system on its head. Therefore, blockchain is a disrupting technology. Typically, disruptive technologies are hard to predict and are often recognized after the fact. Some technologies may facilitate one part of the value chain, while concurrently disrupting another part of the value chain. For example, mobile technologies have facilitated the supplier-facing side for a long time. Now they are now disrupting the customer-facing side as apps continue to bypass in-store purchasing.

Finally, yet another way to classify technologies is based on the broad outcomes that they seek to effect. Based on this classification, technologies could be either commoditizing the current retail offerings or adding value to the existing offerings. For example, a comparison mobile app allows a shopper to easily compare brands or offerings based on price, effectively commoditizing the market. In contrast, the VR technology could offer a radically new immersive experience to a shopper, enhancing the value of the offering.

A summary of these different classifications of retail technologies appear in Table 2. Regardless of how technologies can be classified, their adoption by and impact on retailers need to be carefully studied. While the different classifications help us couch different technologies to better understand their stakeholders, sources, domains, and outcomes, a review of theoretical frameworks will provide us with newer conceptual insights.

Theoretical Frameworks on the Role of Technology in Retailing

Technology plays a critical role in the evolution of retailing. Technologies, in particular, emerging technologies, are significantly impacting the customer experience in general (Hoyer et al. 2020). We can use different frameworks to assess how technology influences retailing evolution. Much of the focus is on understanding how technologies are changing shopper experience and retailer business models. We elaborate on the role of theories and frameworks that may be used to examine the adoption of technologies in retail and highlight how retailers may use the technologies for desired ends.

To explain shopper adoption of technologies or retailer use of these technologies, researchers have used different frameworks, such as innovation adoption model and technology acceptance model.

Innovation Adoption and Diffusion Models

Starting with the Bass (1969) diffusion model of first purchases of consumer durables to the modified or generalized Bass models, technological innovation adoption has been the subject of much research in marketing. The Bass model can be written as:

$$S_{it} = (a + bCS_{it})(M_i - CS_{it}) \quad (1)$$

where S_{it} is the number of adopters of technological innovation i during time period t, CS is the cumulative number of adopters, a, b, and M are parameters, a is the coefficient of innovation or external influence and b is the coefficient of imitation or internal influence, and M is the potential pool of adopters. According to the theory of innovation adoption, a new technology is typically adopted by the cohort of innovators first, followed by cohorts of early followers, early majority, late majority and laggards in that order (Rogers 2003). Furthermore, the distribution of first purchases of innovations typically resembles a bell curve or normal distribution (Rogers 2003). This concept has been used to examine the takeoff of open source innovations as well (Setia, Bayus, and Rajagopalan 2020). It applies to the diffusion of technologies in the retail context well (e.g., ATMs, POS). Beyond adoption at the aggregate level, researchers have used models that focus on individual level adoptions, such as the technology acceptance model (TAM).

Technology Acceptance Model

The TAM has been used to examine the adoption decisions of individuals. TAM offers a theoretical mechanism to explain technology adoption (in particular, IT) in the workplace and argues that the acceptance and use of technologies are driven by

Table 2
Summary of classifications of retail technologies.

Classification	Technology types	Summary
By stakeholder	Customer/shopper-facing	Mobile devices, wearables, smart speakers, AR, VR, and MR systems, IoT, chatbots, smart mirrors, and payment technologies. Retailer facilitation and customer value creation are critical for success.
	Employee-facing	Mobile devices, hand-held scanners, price scanners, IoT, RFID, and smart mirrors. Technologies that involve employee interactions with customers/shoppers need to be managed more carefully.
	Supplier-facing	RFID, IoT, payment, and blockchain technologies. Inventory control, friction reduction, and supply chain resilience and efficiency are key in managing these technologies.
By IT-relatedness	IT based	IT based technologies have a large ecosystem and new retail technologies may have to fit into this system. Investing in upgradation and migration is key to success.
	Non-IT based	Some healthcare technologies are biotech-based and are relevant for pharmacies, retail clinics, health clubs, and fitness centers. Care needs to be taken to ensure shopper safety and privacy for successfully managing the technologies.
By domain span, source of origin	Single versus multiple domain	Some retail technologies may span different types of retail categories (e.g., mobile payment), while others may be specific to a category (e.g., magic mirror for apparel).
	Internal versus external	Retailers can benefit from prior implementation of technologies in other domains.
	Outside-in versus spanning versus inside-out	Some technologies may be in-house, while others are outsourced. In-house retail technologies are expensive, but if it works can provide a source of competitive advantage. Suppliers can push new technologies for retailers to adopt. Retailers can pull suppliers to adopt new technologies. Retailers can work with suppliers to jointly introduce new technologies. Alignment of value between retailers and suppliers is critical for the success of new technologies.
By newness	Incremental versus radical	Newer versions (e.g., 5G telecommunications) constitute incremental changes, while a new solution method (e.g., wireless battery) could be considered radical. Retailers need to plan for greater efforts, investments, and change management when introducing radical technologies.
By nature of change	Facilitating versus disruptive	Some technologies augment current benefits (e.g., Apple Pay) Some technologies upend the system/industry (e.g., Blockchain). Disruptive retail technologies are hard to develop and predict. Retailers need to constantly watch out for them and pivot their business models sooner if they inevitably have to adopt them.
By outcome	Commoditizing versus	Some technologies commoditize current offerings (e.g., price comparison mobile app).
	Value-adding	Some technologies that boost the value of current offerings (e.g., adding a VR system to an existing offering). Retailers need to be wary of commoditizing technologies and have plans to combat them. Retailers should pursue value-adding technologies when feasible.

perceptions about their usefulness and ease of use (e.g., Davis 1989). In the retail context, TAM, and its extended versions, which incorporate additional drivers, have been used to study the acceptance of such technologies as smart virtual closets (Perry 2016), instant shopping (Brusch and Rappel 2019), and AR apps (Rese et al. 2017).

Privacy Lens

Researchers have also used a privacy perspective to examine individual adoption of technologies. Retail shoppers might react positively to non-intrusive retail technologies but negatively to technologies that instigate privacy concerns. When a new technology from a retailer threatens shopper privacy, shoppers will not only resist adopting that technology, but may even engage in negative word of mouth (WOM) or switch to another retailer with a non-intrusive technology. Inman and Nikolova (2017) show that shoppers evaluate a new retail technology on a wide range of aspects, including its intrusiveness on their personal privacy, and that these evaluations impact their patronage and WOM intentions toward that technology. Similarly, Aloysius et al. (2018) find that shoppers' perceptions of the usefulness of

the retail technology together with their privacy concerns impact their usage intention, repatronage intention, and perceived store image.

Performance-Based Framework

Researchers have also studied technology adoption by considering how technologies influence retailer performance. New technologies affect performance in different aspects of the retail business such as product delivery and service delivery (Pantano and Vannucci 2019) and customer service (Setia, Venkatesh, and Joglekar 2013). While consumer adoption of innovations has been well researched, technology adoption by businesses has received less attention. Inman and Nikolova (2017) offer a decision calculus that retailers can use when evaluating the adoption of a new shopper-facing technology. They argue that retailers should make such a decision by considering the benefits of the new technology in increasing revenues, decreasing costs, or both. Importantly, they suggest that in making technology adoption decisions, retailers should consider and evaluate possible shopper reactions. This consideration is important because shoppers' negative reactions toward a technology could lead to the attenuation or even reversal of the potential benefits of that technology.

Despite the availability of the performance-based framework, in practice, technology adoption and spending on technology by businesses significantly lag shopper behavior. For example, although shoppers a substantial portion of their time on mobile and online. Yet, retailer spending on mobile and online technologies is playing catch-up.

Options Value Framework

Retailers could also use a more formal option value based approach for adopting a new technology. The real options framework is a useful lens to analyze investment in new technologies, including in the retail context (Kulatilaka and Perotti 1998). Particularly effective for studying the adoption of platform technologies, the real options framework uses a discounted cash flow approach by conceptualizing technology platforms as investment options for projects that may lead to enhanced revenues (Fichman 2004). Researchers may use technology strategy, organizational learning, bandwagon, or adaption perspectives to evaluate the option value of platform technologies for retailers (Fichman 2004). Furthermore, besides examining adoption, researchers may also examine the ways retailers leverage these technologies for greater performance by building advanced capabilities. A critical challenge in using this framework is that it requires an estimation of uncertainty, which is rather high in the retailing context, in particular, in the COVID-19 and beyond scenario.

Capability-Development Model

Models for technology use often underline the need for developing organizational capabilities (Sambamurthy, Bharadwaj, and Grover 2003). Such capabilities are crucial in customer-side domains of financial services retailers (Setia, Venkatesh, and Joglekar 2013). Setia, Venkatesh, and Joglekar (2013) find that the need for leveraging IT to develop customer-orientation and customer-response capabilities enhances customer service performance in the branches of a bank. This model and related findings suggest that to be successful, retailers can build technology capabilities that engender positive customer emotions (Setia 2020).

Technology Adoption by Shoppers and Retailers

The success of technologies in the retail context depends on adoption by relevant stakeholders, such as shoppers, retailers, employees, and suppliers. We focus on the adoption by the principal stakeholders, namely, shoppers and retailers. Some factors are common to the adoption by both shoppers and retailers, some factors drive only shopper adoption of technologies, and other factors influence only retailer adoption of technologies. We examine the drivers of technology adoptions by shoppers, employees, suppliers, and retailers.

Antecedents/Drivers of Technology Adoption

Among the common drivers of technology adoption, advancement in core technology, consumer push/lifestyle changes, competitor innovation, safety and security, and regulation are key to successful adoption.

Core technology advancement/availability

Most core technologies progress in increments. For example, according to Moore's law, microchips get smaller (half), cheaper, and faster (double in capacity) every 18 months. The next version of a technology is typically available for adoption after the incremental progress period. Sometimes, these advancements are referred to as generational changes. For example, 5G telecommunication represents the generation of communication technology after 4G telecommunication. Such advancements lead to greater adoption. For example, different versions of iPhone starting from the original iPhone to iPhone 11 Pro led to waves of new users adopting the smartphone. The incremental benefits, ease of use, and the smoothness of fit in the ecosystem of these advancements determine the breadth and pace of adoption.

Consumer/shopper push/lifestyle changes

Sometimes consumer adoption of technologies drive retailer adoption of the same or other technologies. For example, consumer adoption of tablets and smartphones accelerated retailer adoption of these devices for their employees. Consumer use of price comparison apps and price bots made retailers upgrade their technology to be listed in the apps and bots and sometimes develop their own price comparison tools. Some retailers have adopted price matching practices through real time technologies that can match prices without human intervention.

Consumer/shopper lifestyle changes also affect retailers' use of technologies. With a growing number of customers adopting busier lifestyles, the order and pick-up habit is on the rise. Many

retailers have responded to this change in lifestyle by creating mobile apps for easy order and pick-up and by operating the mobile channel in addition to their brick-and-mortar and desktop channels.

Competitor innovation

Often, retailer adoption of technologies does not depend mainly on consumer adoption but on other retailers' adoption of similar technologies. Amazon's launch of the cashierless or no-checkout store called "Amazon Go" stores has propelled many retailers to consider launching similar store formats. The movement has picked up steam in the COVID-19 and beyond environment, which calls for social distancing, less human interference, and limited or no cash exchange. Adoption by other retailers, in particular industry leaders, may reduce the perceived risk of a technology for retailers who perceive themselves as fast followers rather than early adopters of technology.

Safety and security

The need for enhanced health, physical and financial safety and security also determines retailer adoption of technology. The need for improved consumer and employee health has led retailers to adopt more store, warehouse, and delivery automation technologies. In the COVID-19 and beyond scenario, more retailers are using automated delivery mechanisms to minimize human contact. To enhance warehouse safety and efficiency, retailers such as Amazon are using robots. The continuous demand for financial security has resulted in retailers adopting more secure systems of payment, including two-step authentication and near field communication (NFC) technologies for contactless mobile pay such as Apple pay, Android pay, and Samsung pay. Emerging technologies such as Blockchain, with its distributed ledger system, can enhance financial security and improve transparency. Other security-enhancing technologies include hardware authentication and data loss prevention. Shoppers' growing use of mobile apps and mobile devices make their password based accounts vulnerable to hacking. To overcome this security problem, an emerging technology bakes authentication into a user's hardware. Intel's Authenticate solution, embedded in its new, sixth-generation Core vPro processor, can combine a variety of hardware-enhanced factors to validate a user's identity. Similarly, data breach and loss can be prevented by encryption and tokenization. As data privacy regulations such as General Data Protection Regulation (GDPR) and California Consumer Privacy Act (CCPA) take hold, these technologies can assist the protection of payment card information (PCI), personally identifiable information (PII) and protected health information (PHI).

Regulation

Regulatory changes are a significant influencer of retailer adoption of technologies. Regulatory changes often mandate retailers to adopt a new technology. Historically, banking regulations have fostered changes in retail banks adopting technologies ranging from ATMs to mobile pay. Sometimes, partner or ecosystem requirements lead to retailer adoption. For example, following requirements from major credit card companies, such as Visa and Mastercard, many retailers installed chip-readers in their stores. Contactless credit cards using NFC technologies are the next generation of credit cards. It does not require users to swipe, dip, or insert their credit cards, avoiding any physical contact with retailer infrastructure. In the COVID-19 and beyond scenario, it will likely gain traction and force retailers to adopt such contactless credit card readers.

Regulations on food safety and produce tracking for perishables across the global food chain have led to the development and implementation of tracking technologies and databases. As a result, shoppers can now better track food to their sources, and the food can enjoy better temperature control and be safer and fresher with fewer recalls and less contamination.

Related issues include ethics and fairness in the use of retail technologies. These issues are in the spotlight for AI based retail technologies in particular. For example, facial recognition technology has been shown to be biased because it is based on machine learning models that are heavily trained on biased data. Furthermore, surveillance technologies such as mobile location tracking and video monitoring may be too intrusive and unethical. For greater discussion on these issues, see Grewal, Haenlein et al. (2020) and Grewal, Kroschke et al. (2020).

Shoppers. Shoppers are increasingly shopping across multiple channels, and omnichannel and multichannel shopping are commonplace (e.g., Neslin et al. 2006; Neslin and Shankar 2009; Kalyanam, Lenk, and Rhee 2017; Kalyanam et al. 2018). In doing so, they are adopting new service technologies such as click-and-collect, mobile check-in, and mobile payment. Shoppers are heterogeneous in their adoption of technologies. Early adopters differ from late adopters in the adoption of multiple generations of technologies of mobile devices that are widely used for shopping (Lam and Shankar 2014). Differences among shoppers in the adoption of IoT can be analyzed using the assemblage approach (Hoffman and Novak 2018). Furthermore, different shoppers adjust differently to robots or humanoids serving them (Grewal, Haenlein et al. 2020; Grewal, Kroschke et al. 2020; Mende et al. 2019).

Retailers. From a retailer standpoint, the key issues relating to adoption are: "what, when, and how" of technology adoption, management of technologies, and strategic versus tactical elements of technology.

Several organizational factors may drive retailer technology budget, risk, and adoption. These factors include technology readiness, organizational agility, organizational inertia, organizational stability, complacency, top management support, mergers, environmental, sustainability and governance (ESG) focus, volatility of sales environment, consumer sentiment, and leaders'/stakeholders' priorities.

Barriers to Adoption

Shoppers, retailers, employees, and suppliers face several barriers to adopt new technologies. These barriers include lack of perceived incremental benefits, increased financial costs, inertia, higher learning costs, and weak network effects. A key to

retailer adoption of technology is employee acceptance. A barrier to employee acceptance is the lag in technology adoption between retailers and individual users. Many employees find their personal technology easier to use than the technologies that retailers provide to them because retail technology could be clunky or out of date due to legacy constraints. Thus, the barriers to adoption for different stakeholders may be intertwined.

Business adoption of some technologies lags shopper adoption of those technologies. For example, many marketers' mobile investments and advertising budgets are not commensurate with the time spent by shoppers on mobile. This phenomenon goes against the typical reason attributed for technology failure – that consumers were not ready for the technology. Some barriers to reducing the shopper-retailer gap in technology adoption include adoption differences between general and targeted shoppers, practical time lag between retailer and shopper adoptions, and retailers' investment horizon. Different retailers target different customer segments and may not necessarily follow the technologies adopted by general consumers. In some cases, there are practical adoption issues, leading to a significant time lag between business value creation and shopper adoption. Furthermore, if a technology takes longer than the retailer's return time horizon to pay off, the retailer may be reluctant or slow to adopt that technology. Some cases require investments in complementary assets for retailer adoption. Examples include investments in POS system upgradation and mobile responsive website updates that might require investments in complementary assets such as a cloud based customer data platform infrastructure and machine learning expertise.

Grocery pick-up is an example of a retail technology where shopper adoption was ahead of business value creation. Grocery pick-up was available at multiple retailers in multiple countries much before COVID-19. In some countries such as India, it was a competitive necessity for retailers. However, many retailers in the U.S. did not embrace it as they found the economics of the use case to be ambiguous. Order sizes and frequency were low as many customers were using it mainly for items they had forgotten to purchase on their weekly replenishment trips. Still, with an eye on the future, some retailers took risks and made initial investments in this technology. However, during COVID-19, both shopper and retailer adoption of it has been continuously growing with many shoppers using it to purchase their entire shopping basket. With the increased volume, many retailers have been able to fill more orders accurately with more fresh products, fully realizing the business value of grocery pick-up. Nevertheless, retailers who adopted grocery pick-up early are enjoying the returns to adoption, while those who were late are still playing catch-up (Del Rey 2020).

Outcomes of Retailer Adoption

Depending on the stakeholder, different outcomes of retailer adoption may be important. From a shopper/customer standpoint, the key outcomes include satisfaction, purchase, and repeat purchase. From a supplier perspective, outcomes like out-of-stock/shelf and on-time delivery are important. From the retailer's own viewpoint, outcomes such as revenues, market share, customer satisfaction, profits, employee satisfaction, and shareholder value are the key consequences of retail technology adoption.

Retailer decisions on adoption

The retailer's decision to adopt a technology comprises the following issues: What technologies to adopt at what moment in time, with how much investment, and what path, sequence of action, or execution. These decisions are typically made based on an assessment of risk and cost-benefit analysis. Some of the risks are soft, including the risk of non-adoption, that is, if a retailer fails to adopt a technology, will it lose its customers to its competitors?

What? The decision on what technologies to adopt is a challenging one. Often retailers have to adopt one technology at the expense of another. Key considerations include track record, reliability, potential impact, time horizon, speed of adoption, cost, learning, and cost of transition or disruption. Many times, technology adoption decisions are irreversible. Because retail margins are typically low, retailers are typically wary of choosing the wrong technology.

When? The timing of technology adoption is critical. In many cases, the timing is tied to the technology in question. Retailers typically want to adopt a technology when their shoppers and employees are ready to embrace them, not too early or too late. Chain retailers have the opportunity to test technologies in a few test stores before rolling them out throughout the chain.

How much to invest? This is a key decision for most investors. Different technologies have different price tags. Most retailers do not have big budgets to make big investments. However, retailers such as Amazon have deep pockets and technology is their forte. Therefore, such retailers can use technology investment as a competitive advantage tool. For example, Nordstrom decided to invest in technology early on despite being aware of the long horizon for fully realizing the return to that investment.

How to execute? Retailer decisions on technologies live and die by their execution. Implemented well, most technologies can bear fruit. In contrast, poor execution can hamstring the success of retail technology adoption. Examples of good technology implementations are: Hema's QR code, Specsaver's frame styler tool, Nike's speed shop, Zara's self-checkout, Target's mobile wallet, Audi's VR showroom, and Sephora's beauty hub. In contrast, many retailers have experienced failure in implementing customer relationship management (CRM) systems. Often due to lack of vision, poor planning, and not putting the customer at the center, resulting in poor user adoption. As noted earlier, the ability to use test stores to validate expectations and fine tune systems can improve success rates.

Retailer management of technology. Retailers need to make choices about how to manage technology. A retailer can completely own the technology, jointly own it with one or more partners, or outsource it to a third party. A special case of third party technology management is open innovation, where the retailer relies on external solutions that address a general problem or challenge. Retailer management of technology is based

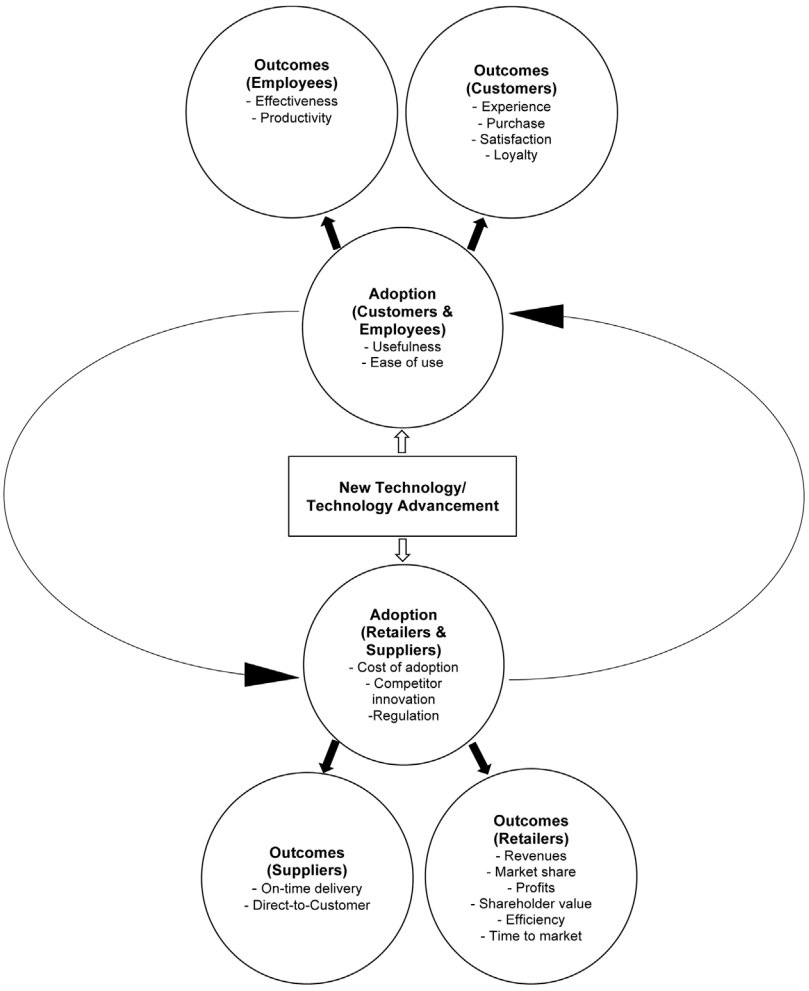

Fig. 1. Antecedents, outcomes, and forces at play related to technology.

on know-how, learning, skill development, and surmounting of adoption barriers (Attewell 1992).

Retailers take into account both strategic (long-term) and tactical (short-term) considerations in making the technology management decision. An important area of concern for retailers is how to evaluate the success of a technology. Different approaches to evaluation exist.

A key consideration in making the technology management decision is access to talent. For mature technologies, retailers may be able to acquire talent. However, for emerging technologies, most retailers may find it challenging to attract or retain the best talent. Skilled technologists in emerging areas are more likely to work for technology-focused companies than for retailers. Thus, working with an expert in an emerging technology may give retailers the best access to the best talent. People or human capital and technologies are complementary assets.

Data security is a critical issue in managing technology. If financial and other personal data on customers and employees are at risk or are hacked, there would be huge ramifications on outcomes such as customer trust, employee trust, customer satisfaction, employee satisfaction, sales, and market share. Since 2018 alone, at least 19 retailers and consumer firms have experienced data breaches (Green, Hanbury, and Cain 2019). Many of these data breaches were related to security holes in payment systems.

Fig. 1 captures the antecedents, outcomes, and forces at play relating to technology. Because technology is the focus of our research, new technology or technology advancement is at the center of this framework. The adoption of technology by the key stakeholders, customer/shopper, retailer, and supplier form the other boxes around this central box. The outcomes of technology adoption by customers and retailers appear in the other boxes. The arrows capture the directions of impact from key drivers. While we cannot capture all the forces with a single figure, we show the key forces at play in Fig. 1.

Future Scenarios and Research Questions

We discuss possible future scenarios under five areas: smart distancing, retailer disintermediation, hybrid bundles, sharing economy, and new retailer types.

Smart Distancing

In the COVID-19 and beyond world, retailers may have to embrace and implement technologies that offer shoppers

significant benefits, while keeping the shoppers and employees safe. This situation calls for minimization of human contact and maintenance of social distance. We envision a scenario where retailers adopt what we call "smart distancing" practices. For example, some retailers are testing a new system called Smartdome, an in-store technology comprising IoT sensors, video cameras, and a public address audio system, that monitors shoppers inside a store and announces when shoppers deviate from the social distancing norms (PYMNTS 2020). Other smart distancing applications include automated drone delivery, robot delivery, and drive-through delivery. Other considerations include the redesign of store layouts to enable one way traffic and to declutter retail stores so that in-store browsing can follow social distancing guidelines. Some retailers could offer certified or guaranteed hygiene measures to differentiate themselves. However, if most retailers start offering such guarantees, the hygiene measures may become table stakes for retailers to compete. As scientific knowledge on health and infectious diseases evolve, we expect such guidelines to also change. Such continuous evolution requires retailers to have a flexible approach to incorporate changing guidelines.

Disintermediation of Retailers

This scenario involves manufacturers and service providers bypassing retailers to supply direct to consumers. For example, consumables such as printer ink and dishwashing liquid may go direct from the manufacturer to the consumer. Printers and washers may automatically reorder directly from the manufacturer when their supplies run below a floor level. A scenario in which all consumables such as laundry detergents for washers are replenished by AI in the machines directly ordering with the manufacturer and the retailer becoming more of a repair agent is being tested by Proctor and Gamble. In such a scenario, to avoid being eliminated, the retailer may become a fulfillment partner of the manufacturer. Refills for many regularly ordered prescription medications are already being delivered directly to consumers based on a refill schedule instead of requiring shoppers to visit a retailer. Some of these prescription replenishment programs are through insurance companies. But some are set up by the retailers like Walgreens. Amazon's "Subscribe and save" is one such retailer replenishment program.

Hybrid Bundling of Goods and Services

More products and services could be sold as bundles by retailers. Such bundles, called hybrid bundles, are becoming popular among retailers (Shankar, Berry, and Dotzel 2009; Meyer and Shankar 2016). Best Buy's TV purchase and installation service and Home Depot's carpet buying and installation services are good examples of hybrid bundles. Technologies enable retailers to develop and sell creative bundles. In some cases, retailers could use such bundling as a defense against technological disintermediation.

Sharing/Gig Economy

In the future, the sharing or gig economy is likely to gather momentum. More products will likely be rented and shared among users. Rent-a-runway is a good example of a retailer that allows shoppers to rent clothing items. Retailers such as Nordstrom and Macys are serving as distribution points for such new retail concepts. This development is captured in Fig. 1. One perspective is that technology shrinks existing markets with disintermediation and opens new markets with innovation. However, the pandemic has made shoppers wary about sharing things. For example, shared rides in Uber and Lyft has virtually disappeared due to social distancing concerns. Nevertheless, the pandemic has also diminished disposable incomes and accelerated shoppers' purchases of used fashion (Kavilanz 2020). Perhaps the retailer should take this perspective into account in formulating its future strategies.

New Retailer Types

In the future, we will likely witness the emergence of different types of retailers. These retailer types include smaller format store, new product demonstration store, renting store, pop-up store, repair store, community store, grocerant, and retail as a service firm. Perhaps, new forms of selling will also be a part of new markets.

Small format store

Small store formats are already present in many places. Walmart's neighborhood markets, Best Buy express stores, and kiosks at airports represent this format. Similarly, IKEA launched small format IKEA City store concept in the U.S., starting with the IKEA planning studio (Schwab 2019). In the near future, in addition to pervasive omnichannel retailing, there will be more of such small format stores to meet shopper needs for quick replenishment and instant gratification. This format could share a number of similarities with convenience stores in terms of retail density and location.

New product demonstration/showroom store

These stores predominantly showcase and demonstrate new products to build excitement and interest among shoppers. Shoppers can order products and can have them shipped to their homes from these showroom stores. Warby Parker showrooms and Bonobos guideshops are examples of such stores.

Pop up store

There will be more pop up stores that will be launched primarily by pure play online retailers or direct to consumer (DTC) marketers or other retailers to sell seasonal items. Unlike showrooms and guideshops that exist around the year, these stores are temporary and close down after serving their purpose.

Renting store

Another scenario involves consumers sharing or renting almost everything including, housing, clothing, and transportation. Rent-a-runway is an example of such a store for apparel. In

such a scenario, there will be greater demand for product variety and lesser need for mass production and inventory. Retailers will also need to become more skilled in predicting customer preferences and offering products and services, much like what Netflix does for movies.

Repair/return store

These stores will be dedicated for repairs. Shoppers can visit the stores and return items needing repair. Depending on the item and the type of repair, shoppers can receive the repaired items in the same trip, another trip, or even get them delivered at their home. In this case, the retailer functions as a repair agent. Today's examples include Apple store's genius bar and cell phone repair shops.

Large/immersive experience store

These stores are large concept stores that market the brand. Typically, these stores serve as showrooms for the manufacturer or service brand. Shoppers can visit the stores, immerse themselves in different facets of the brand, and experience all the brand has to offer. Examples of such stores are Niketown and the New York Samsung 837 store that is a digital playground for shoppers.

Community retailer

Some malls are being replaced by community centers. An example of such a center is the Palisades Center in West Nyack, New York that comprises a bowling alley, a comedy club, and an indoor rope-climbing wall (Sanburn 2017).

Grocerant

Each of these stores combines a grocery shop and a restaurant. These stores blur the distinction between a grocery store and a restaurant. They aim to tap the busy shopper and provide a complete experience. Already, restaurants in warehouse clubs such as Costco and Sam's club have busy restaurants that extend shopping time, enhancing basket size.

Retail as a service firm

This store combines good design with a showroom that may include store-within-stores and provide shopping as a service. B8ta, a retail store that enables consumers to experience products out of-the-box and enables brands to place their products online and analyze experience, is an example of this format In the COVID-19 and beyond environment, more retailers will have "retail-to-go" service, where shoppers order and collect the items they ordered in the store. Such a practice will enable minimize human contact and conform to safe distancing norms.

Future Research Questions and Avenues

The potential future scenarios suggest several interesting questions for future research. The current delivery or logistics economics for printer ink suggest that manufacturers can easily replenish these categories without retailer participation. Consumer repurchases across home office categories like paper, supplies and ink do not seem to be synchronized to warrant a joint shopping or a fulfillment trip. In this regard, manufacturers face a dilemma. They need retailers more to sell their products and less to replenish supplies. Therefore, many manufacturers also sell supplies directly to consumers. The computers and printers category appears to be gravitating toward this scenario. In contrast, in categories such as washing machines, manufacturers do not appear to be selling supplies directly to consumers. For example, LG has decided to partner with a retailer like Best Buy to sell supplies to consumers. What category moderating factor causes different disintermediation outcomes? This issue needs to be actively incorporated in the model and perhaps is also a question for future research. Related questions are: Under what conditions will technology cause disintermediation? How can retailers use technology to create a moat against disintermediation?

Future research could also investigate the impact of technology on not just retail outcomes but also on the whole retail ecosystem. Some technologies may have an impact on just retailing, while others may have an impact on the retail ecosystem as a whole (trickle-up). The impact may also be trickle-down in that some technologies such as blockchain might start with the ecosystem and trickle-down to elements of the ecosystem. While few technologies have trickle-up effects, trickle-down innovations may not be that effective (Zhang et al. 2019). What types of technologies disrupt the ecosystem? Under what conditions are the disruptions high or low?

Perhaps one of the biggest insights that we offer is that disintermediation and the ability to enter new markets are significant drivers of technology adoption and are an important part of the antecedents and outcomes framework. These insights might change how retailers view technology, accelerate adoption, and make evaluation more holistic. In addition, we also focus on time to or time required for adoption. This is a crucial variable and might significantly influence whether the retailer will get disrupted or not.

Retailers also face a "make" or "buy" decision with respect to certain types of technology. They also have to make tradeoffs with respect to cost and time to market. "Make" decisions are generally viewed as cheaper, but such a view might be a fallacy. The total cost of ownership should be considered. We need more evidence of the relative benefits of the two options. Retailers should also consider outright "buy" decisions. Amazon's purchase of Kiva Robotics or Walmart's acquisition of Jet.com for their ecommerce platform are examples of such a decision. Perhaps, the retailing industry is like a "technology" industry. Retailing changes at the clock speed of technology, which suggests that retailers could use the strategies that technology companies adopt to avoid disruption.

Methodological Challenges

To research the identified substantive issues, researchers face a number of methodological challenges. First, for establishing the causality of the effect of retail technology adoption on outcomes or for estimating the impact of the drivers of technology on retail adoption, researchers often need field experimental data. It is not only expensive to run field experiments but in many cases, it is infeasible and unethical to use them. For exam-

Table 3
Future scenarios and related research questions.

Future scenario	Future research questions
Smart distancing	What technologies lend themselves to smart distancing?
	What smart distancing technologies will add value to the shopper?
	How will shopper behavior change with smart distancing?
	How can retailers trade off safety and business value in enforcing smart distancing?
	What combination of automation and human employment is ideal for smart distancing?
	What business model will work best for smart distancing technologies?
Retailer disintermediation	What types of retailers will likely be disintermediated?
	What product categories are most ripe for disintermediation?
	Why are some categories disintermediated, while others are not?
	How much of revenues will likely be disintermediated?
	How should retailers partner with manufacturers for leveraging disintermediation?
	What technologies cause disintermediation?
	What technologies should retailers use to defend against disintermediation?
	What business models work best for a retailer-manufacturer win–win amid disintermediation?
	Should retailers "make" or "buy" technologies to manage disintermediation?
Hybrid bundling	What hybrid bundles work best for retailers? Why?
	How do shoppers choose hybrid bundles? Why?
	How can retailers influence shoppers' choice of hybrid bundles?
	How should retailers price their hybrid bundles?
	How can retailers use technologies to create new hybrid bundles?
	How should retailers partner with manufacturers and service providers to create winning hybrid bundles?
Sharing/Gig economy	What products/services/items are most amenable to sharing? Why?
	How do shoppers choose and use shareable offerings? How can retailers influence their choices?
	How should retailers use technology to manage shareable products and services?
	How should retailers price sharing economy products and services?
	How can retailers customize sharable offerings to customers?
	What AR, VR, MR, IoT, and AI systems should retailers use to manage their rental businesses?
Retailer types	What product categories are most suitable for small format, new product demonstration, pop up, renting, repair, experience, community, grocerant, and repair-as-a-service retailers?
	How do shoppers behave in new types of retail stores? How does the behavior differ from that in conventional retail stores?
Methodological challenges	How should retailers leverage technology to choose different store types?
	What technologies are scalable for adopting new retailer types?
	How does technology impact the emerging retail ecosystem?
	How to establish the causality of the effect of retail technology on shopping outcomes?
	How to estimate the causal impact of the drivers of technology adoption on adoption?
	How to obtain data on retailer adoption of technology
	How to get data on shopper use of technology from technology firms like Apple, Amazon, Google and Microsoft?

ple, to study the impact of a technology failure like mobile app failure on shopping outcomes, a retailer cannot run a randomized control study in which some shoppers experience failure. In such situations, natural or quasi-experimental research would be most appropriate (e.g., Narang, Shankar, and Narayanan 2020).

Second, while data on shopper adoption of technologies are more commonly available, data on retailer adoption of technologies are hard to collect. Using syndicated data collected by technology research firms like Gartner may be one way to analyze retailer technology adoption.

Third, increasingly technology firms that collect shopper data, including Google, Facebook, Amazon, and Apple, are not sharing the data with academic researchers. A university-industry partnership consortium is critical to break this deadlock.

A summary of the description of future scenarios and related research questions appears in Table 3. The future research questions in this Table 3 are more exhaustive than the questions discussed earlier. By grouping the questions against the future scenarios, we offer a rich set of future research avenues by topic.

Conclusions

Technologies are evolving fast. Many of these technologies are substantially altering the retailing landscape. New technologies such as micro-cloud computing, robotics, 5G, VR, AR, MR, IoT, and drone are significantly reshaping retailing. In particular, in the COVID-19 world, technology is allowing retailing to pivot in the face of new and unforeseen circumstances. Our review of technology classification, the frameworks for understanding technology's role in retailing, and the antecedents and outcomes of technology adoption, offers a broad perspective and a deeper understanding of technology and retailing. We hope that the future scenarios we sketch and the research avenues we outline would help spawn fresh ideas and spur new research.

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