Commentary

Customer-Interfacing Retail Technologies in 2020 & Beyond: An Integrative Framework and Research Directions

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Abstract

The world of retailing is changing rapidly, and much of that change has been enabled by customer-interfacing retail technologies. This commentary offers a framework for classifying technologies, based on their primary influence on a customer's purchase journey – in the pre-purchase stage, needs management and search engagement technologies; in purchase stage, purchase transaction and physical acquisition technologies; and in the post-purchase stage, follow-up service and loyalty management technologies. We then discuss and classify forty recent retail technologies according to this framework. Finally, we identify areas that offer great potential for further research on retail technology.
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New technologies clearly are revolutionizing retailing. The first two decades of the 21st century have witnessed tremendous changes, especially related to the proliferation of the Internet and its accompanying tools and capabilities. Online retail, webrooming, digital payment systems, and mobile shopping have become the norm; additional, novel options are growing in number and familiarity too. Technological developments in retail seem likely to accelerate in 2020 and beyond, involving expanded applications of artificial intelligence, machine learning, virtual reality, big data, and mobile apps. With this commentary, we seek to provide a new conceptual framework for understanding retail technologies, fit recent retail technologies into this framework, and offer directions for continued research. In particular, we introduce and illustrate 40 recent retail technologies according to our framework, and identify ten areas that offer great potential for further research on retail technology.

For the purposes of this commentary, we define recent retail technology to include apps, devices, tools, techniques, models,

and enablers that (1) use some feat of engineering, analytics, or digitization; (2) are linked to retail activities; and (3) have been developed since 2000. This definition thus encompasses, for example, robots, virtual mirrors, and the Internet of Things (IoT), introduced in this century, but not self-checkout and RFID, introduced prior to 2000. Among these recent retail technologies, we focus mainly on front-end offerings that inform the retail interface with current or potential customers—that is, on customer-interfacing retail technologies. There is a host of back-end technologies that facilitate retail operations (e.g., agile supply chains, dark analytics, crypto coins, RFID, employee management automation), related to supply chains, logistics, delivery, vendor management, and assortment planning, but, we do not focus on these back-end technologies in this commentary.

To position our new framework, we first consider two existing frameworks of customer-interfacing retail technology, then explicate our new, integrative framework by relating customer-interfacing retail technology to their impacts on customer journey stages. We conclude with a discussion of the impact of the COVID-19 pandemic on uses of these technologies, as well as with some directions for further research.

Existing Retail Technology Frameworks

We know of two typologies proposed previously to represent customer-interfacing retail technologies, by Sethuraman and Parasuraman (2005) and Grewal et al. (2020). Both frame-

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works organize retail technology according to two dimensions that reflect how technology might affect consumers. First, Sethuraman and Parasuraman (2005) classify retail technologies by cost and service dimensions. They propose that cost refers to all costs related to making the product available for sale to end consumers, including product acquisition, delivery, inventory, ordering, and so forth; at the customer interface, they generally manifest in retail price. Then they define "services" as "a catch-all phrase to represent the variety of non-price store attributes (e.g., location, product assortment, and sales assistance), supplementary services. . ., and convenience aspects . . . that contribute to customers' overall experience with retailers" (Sethuraman and Parasuraman 2005, p. 107). Based on these conceptualizations the authors classify technologies as primarily *cost-saving* or *service-enhancing*, while also acknowledging that cost-saving technologies can increase, decrease, or have no effect on customer service, just as service-enhancing technologies can increase, decrease, or have no effect on product costs or prices. Accordingly, they propose six types of retail technologies:

(1) Cost-saving technology that does not affect service levels (e.g., cross-docking intended to reduce inventory costs).
(2) Cost-saving technology that reduces service levels (e.g., automatic self-checkout lanes).
(3) Cost-saving technology that enhances service levels (e.g., Radio Frequency Identification or RFID).
(4) Service-enhancing technology that does not affect costs to consumers (e.g., biometric thumbprint identification instead of signatures).
(5) Service-enhancing technology that may increase costs to consumers (e.g., navigation or payment system attached to grocery cart).
(6) Service-enhancing technology that can result in potential cost savings for customers (e.g., e-commerce).

With this framework, Sethuraman and Parasuraman (2005) detail how technological investments could increase the attractiveness of retail offerings in terms of lower prices and higher levels of service, especially for retailers catering to the Big Middle (majority of consumers).

Second, Grewal et al. (2020) offer a technology–touchpoint typology focused on convenience and social presence dimensions. Convenience represents all the benefits a consumer experiences from using in-store technologies. For example, scanning a QR code grants consumers immediate access to a wealth of information about the product, available on their mobile phones. Social presence connotes the feeling that another human being is present (Biocca and Harms 2002), regardless of whether a physical person is there. For example, both embodied and disembodied robots can evoke social presence. With these dimensions, Grewal et al. (2020) propose four types of technologies:

(1) Low convenience/low social presence (e.g., digital price tags).

(2) Low convenience/high social presence (e.g., inventory robots).
(3) High convenience/low social presence (e.g., self-checkout)
(4) High convenience/high social presence (e.g., Amazon's Alexa).

Although they offer helpful insights, both of these frameworks are attribute- or benefit-driven, rather than process-driven. That is, they classify each technology according to whether it provides cost savings, service, convenience, or social presence, not according to its role in moving customers through their purchase journeys. Furthermore, they do not incorporate many online retail technologies that have become critically important to retail success in an omnichannel world. As an alternative, our proposed framework of customer-interfacing retail technologies conceives of retail technology primarily as an enabler and enhancer of a customer's purchase journey.

Customer-Interfacing Retail Technologies: A Customer Journey Framework

Broadly speaking, a customer journey involves three stages: pre-purchase, purchase, and post-purchase. Retailers need customer journey management systems to understand detailed features of each customer journey and how to manage customer experiences to move them along the journey (Grewal and Roggeveen 2020). Such understanding cannot be complete without a clear sense of how different customer-interfacing retail technologies direct the journey. Most of the vast multitude of technologies that have been developed since 2000 to enhance retailers' interfaces with customers aim to improve customer awareness, engagement, or experience with products. Thus, it seems natural to link such technologies to customers' purchase journeys, as in Fig. 1, in which we classify customer-interfacing retail technologies according to the customer journey functionality that they primarily facilitate.

The pre-purchase phase encompasses all customer interactions with the brand prior to purchase, typically comprising of need recognition, search, and consideration (Lemon and Verhoef 2016). In this stage, technology can help customers identify their own needs better and search for appropriate product options. In our framework, the pre-purchase phase thus includes needs management technology and search engagement technology. Then the purchase phase encompasses all customer interactions that take place to make the purchase, such as choice, ordering, and payment. The assistance provided by technologies therefore should help the customer in acquiring the desired product and completing the purchase; in our framework, purchase transaction technology and physical acquisition technology are the essential features during the purchase phase. Finally, the post-purchase phase represents all customer interactions with the brand after the purchase has been completed—usage and consumption, post-purchase engagement, and service requests. Technologies often determine the follow-up service offered to the customer, as well as help manage the loyalty program. In our framework, we classify post-purchase customer-interfacing
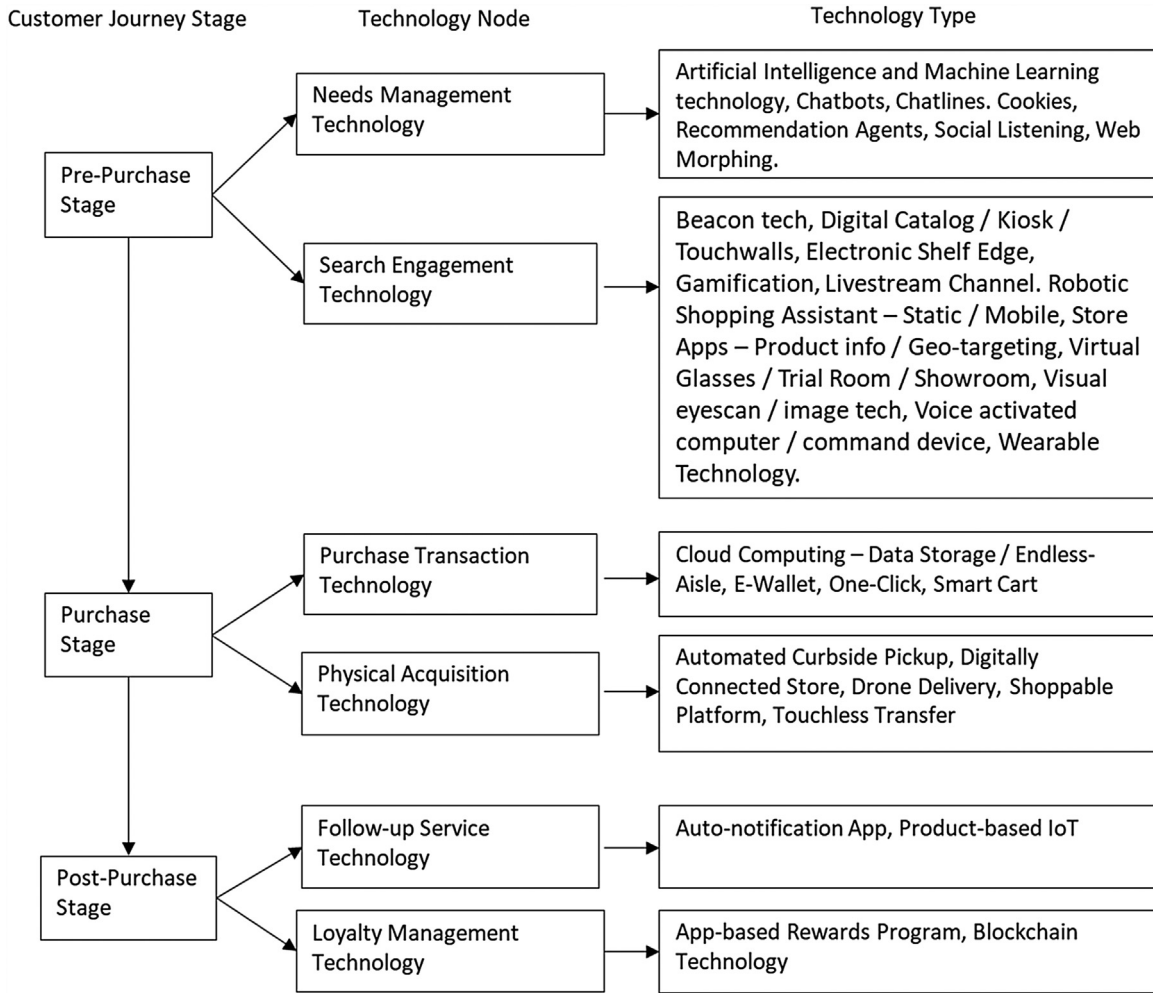
Customer Journey Stage   **Technology Node**   **Technology Type**

Fig. 1. Recent customer-interfacing retail technology: a customer journey framework.

Notes: The technologies, arranged in alphabetical order within each node, are classified by the stage of the purchase journey in which they have the most influential role. Many technologies apply to more than one stage though. Table 1 provides more details about the technology types. Furthermore, this technology list is not meant to be exhaustive; new technologies are introduced continuously.

retail technologies as follow-up service technology and loyalty management technology.

We describe how various technologies fit into these different nodes and functionalities in more detail next. We classify each of the technologies that have been introduced since 2000 according to one of the nodes or technology subgroups, but we recognize they also might enhance more than one node. Table 1 lists the different types of customer-interfacing retail technologies that are most appropriate for each node.

Retail Technologies for the Pre-Purchase Stage of the Customer Journey

Consumers are driven or motivated by their needs and wants; once they identify their needs, they engage in a search for alternatives to satisfy them. We divide technology in the pre-purchase stage accordingly.

Needs management technology

Technologies devoted to customer needs management enable data collection and analysis efforts to understand customer needs, then provide personalization and recommendations to respond to those needs. Tactics to assess, anticipate, and manage needs are crucial to manufacturers and sellers that seek to design appealing product offerings, as well as to retailers that try to design an optimal portfolio of products. Technology enables needs assessment and management through more effective data collection, data snooping, data analytics, and social media listening methods, reflecting the role of data as the source of the power of good needs assessment technologies. Such data can come from cookies that follow a consumer's online search, summaries of actual purchase behavior, and models or algorithms, many of which deploy artificial intelligence (AI) or machine learning (ML) techniques. Although AI and ML often are used interchangeably, they differ. Whereas AI combines different technologies to enable machines to sense, comprehend, act, and learn with human-like levels of intelligence, ML refers to the process by which a system learns patterns from data and improves through experience. The two technologies clearly are related and have a similar purpose, namely, to harness data to the fullest extent possible. They thus form the foundation for many already deployed data-oriented retail technologies.

Table 1
Customer-interfacing retail technologies examples.

#	Name	Definition/details	Application/comments
Pre-purchase stage: needs management technology			
1	AI & ML technology (related)	Artificial intelligence (AI) combines different technologies to enable machines to sense, comprehend, act, and learn with human-like levels of intelligence. Machine learning (ML) is the process by which a system learns patterns from data and improves with experience	Amazon and Netflix allegedly use customers' web browsing and purchase data, combined with AI and ML, to design their private-label new product offerings. Many other technologies (e.g., chatbots, recommendation engines) also use AI.
2	Chatbots and virtual shopping assistants	Retailers connect with potential buyers virtually to answer common questions. Increasingly relies on AI technology with no human presence on the selling side	Chatlines help retailers engage in person-to-person digital conversations, such as on a website, and at least half of *Fortune* 5000 companies have experimented with chatbots, hoping to reduce costs and improve response quality.
3	Chatlines	Similar to chatbots but featuring with a human presence on the seller side	
4	Cookies for data collection	Collects web browsing and purchase data and analyzes them using models or ML to assess and respond to customer needs	Most online companies use cookies to collect and process data about customers.
5	Recommendation agents (RA) or engines	Recommend products to customers based on current and past browsing and purchasing behavior using AI/ML	Retailers such as Amazon and Best Buy use RAs to suggest similar, substitute, or complementary products for purchase.
6	Social media listening	Using text analytics and AI to listen to social media conversations and gain insights about customer needs	A restaurant learned that its burritos were frequently mentioned on social media but mostly negatively, suggesting the need to improve.
7	Web-morphing personalization	Analyze data as customers browse, then dynamically personalize product offerings, prices, promotions, and communications	Used by airline companies, online travel agencies and other web aggregators.
Pre-purchase stage: search engagement technology			
8	Beacon technology	App- or cart-based technology that provides information about product, prices, and promotions as people move a cart or mobile device through physical aisles. Can also suggest optimal navigation paths through aisles	Carrefour customers can use mobile devices attached to shopping carts to receive in-store routes and personalized promotions. As customers are guided around the store, beacons collect data about their behavior and purchases.
9	Digital catalog	Similar to physical product catalogs but be enabled on digital devices, which provides touch capabilities, information, filtering, and purchases	A leading European furniture retailer introduced a digital catalog app to help shoppers envision and search/buy selected products through smartphones or tablets.
10	Digital kiosk	Information available in a physical or digital catalog that also can be accessed on large screens with touch features	Pilot versions feature large, interactive surfaces with multitouch features and offer product videos, statistics, product comparisons, and reviews.
11	Digital/touch walls	Using near-field technology and touch to merge physical and digital worlds, such that touching a spot on the digital wall prompts rich product and inventory information	Traditional retailers are adopting subscription models and use "touch walls" to display online-only inventory and provide product information about each item touched.
12	Electronic shelf-edge technology/E-ink	E-ink or color displays replace traditional paper-based labels. Reduces time and effort required to print and change labels manually	In addition to supporting dynamic pricing, these displays can be used for targeted communication and display product reviews or recommendations.
13	Gamification	Use game mechanics to engage a customer during the purchase journey	Johnson & Johnson created gamification boards that children and parents can use to make purchases.
14	Livestream channels	Similar to Home Shopping Network, except real time and interactive, such that a salesperson takes customers through a virtual tour of items in the store, answering questions and accentuating products	Becoming popular among luxury goods retailers in the United States and China.
15	Robotic shopping assistant, static	Static robots, usually located at the door or aisle entrances, provide prices and other information and aisle guidance	Lowe's LoweBot robotic assistant helps provide in-store customer service.
16	Robotic shopping assistant, mobile	Similar to static robots but with autonomous mobile features, so they can walk aisles, point, or pick up items for customers	Often used for back-end order processing by retailers such as Amazon, with the potential to augment or replace front-line sales.

Table 1 (*Continued*)

#	Name	Definition/details	Application/comments
17	Store apps, product finder	Apps guide customers by making recommendations, revealing where items are located, and plotting a store map	Penetration of apps for major retailers like Costco and Walmart is growing among consumers.
18	Store apps, geo-targeting	Apps inform and guide customers to the nearest store	Starbucks uses geo-targeting to prompt customers to enter a store as they are passing by.
19	Virtual glasses and camera tech	By taking selfies, consumers can see how the product looks on them in 3D views	Jewelry retailer CaratLane's buyers can use its mobile app to see how its products will look before placing an order.
20	Virtual trial room, AR	New technologies like the 'memory mirror' provide 360-degree video of consumers, which can be saved in the app for later online or in-store purchases, as well as send them to others for comments	Online clothing store Bonobos opened several "guideshops" for customers to find items with appealing fit and style, try them on in the virtual room, then order and have them delivered to their homes.
21	Virtual showrooms	Allows customers to see how product will look in their homes or personal settings	The IKEA ARKit shows how furniture will look to see if it will match existing curtains, wall color, and flooring.
22	Visual eyescan technology	Holding a product icon at eye level on the digital device leads to provision of product information or to complete purchases	A U.S.-based e-commerce retailer launched a virtual store in Australia, allowing shoppers to scan over 12,500 products without any store visit.
23	Visual image technology	Allows consumers to search visually for products by providing an image or locking on an image or product icon	H&M and Walmart have purchased visual search technology from third parties and are trying to develop their own versions.
24	Voice-activated/touch-free computers	Activated through voice commands and can provide shopping information	Likely to become popular in physical stores during and after the COVID pandemic.
25	Voice command technology	Devices that answer questions related to shopping. Can also make purchases	Alexa and Echo by Amazon.
26	Wearable technology	Smart electronic devices that can be worn on the body as an accessory and support physical or online retailing.	Shopping with Apple Watch in Whole Foods, viewing products with Google glass, paying by bracelet with Barclay card.
Purchase stage – purchase transaction technology			
27	Cloud computing, data storage	Allows retailers to store extensive data related to products, inventory, and purchase transactions	Used by most retailers.
28	Cloud computing, endless aisle	Allows salespeople to check inventory and find products online, if not available in physical store.	Used by most durable goods retailers that cannot carry all items/parts in physical stores, such as Best Buy and Home Depot
29	E-wallet	Automatic debiting upon purchase	Apple Pay; Samsung Pay
30	One-click order	Combines fast checkout with e-payment	Popularized by Amazon.
31	Smart cart technology	Consumers can place the items they purchase in the cart and leave; the cart scans the items and charges an account (combination of beacon and e-wallet technology)	Amazon Go app allows for "Just Walk Out" shopping experience, which leverages multiple technologies such as computer vision, sensor fusion, and ML. The virtual shopping cart tracks items and when leaving the store, the shopper's Amazon account will be charged.
32	Shoppable platforms	Social media and other platforms adding a shopping facility for users	Albertson's has enlisted Pinterest to highlight its range of private-label products and glean more insights on food and beverage consumption trends.
Purchase stage – physical acquisition technology			
33	Automated curbside pickup	Scan code, get products put in car	Offered by Walmart, Target, and many other physical stores.
34	Digitally connected store	Connects multiple stores with different product inventory, resources, or capabilities	Minkoff partnered with eBay and Magento to create a digitally connected store, which uses "connected glass shopping walls" and digital fitting rooms
35	Drone delivery	Delivers to remote locations at the appointed time using a drone	Offered by Pizza Hut in some locations.
36	Touchless transfer	No human touch, from production to delivery	Domino's Pizza advertises that its pizza is not touched by a human, from the moment it goes into the oven until it is delivered to the customer's doorstep.

Table 1 (*Continued*)

#	Name	Definition/details	Application/comments
Post-purchase stage: follow-up service technology			
37	Auto-notification app	Automatically notifies customers when the next replenishment or refill is due	Used especially by pharmacies like Walgreens and CVS.
38	Product-based IoT	Alerts consumers about parts or accessories and replacements and suggests where to buy them	Car dealers like Sewell Lexus and appliance retailers like Best Buy inform consumers beforehand when the next service is due or part is to be replaced.
Post-purchase stage: loyalty management technology			
39	App-based rewards program	Allows consumers to manage their rewards program	Starbucks expanded its loyalty program by introducing points for purchases outside of retail locations and making the rewards management process interactive through mobile apps.
40	Blockchain technology	Records information in chronologically linked, immutable blocks to foster safety, trust, and transparency.	Used by airlines to track actual travels by customers for rewards management and to enhance loyalty.

The data they collect, in combination with analytical tools and techniques, can inform product offering designs, produce recommendations, and influence consumers' thinking, especially in online marketplaces.

The online retail giant Amazon offers a good case in point. According to some reports by former employees, Amazon relies not only on massive data involving third-party sales made through its website but also snoops and uses information about competitors' sales to determine how to design and price its own private-label products (Mattioli 2020). Even as Amazon denies these allegations, the idea reflects the tremendous potential for online platforms to draw from their vast data to understand customers' needs and design new and private-label products. Thus companies such as Amazon but also Netflix and Airbnb likely can predict, with a high degree of accuracy, what customers want, sometimes even before they realize they want it. If a retailer can offer relevant, targeted products to a customer in the pre-purchase stage, such as through recommendation engines, it can shorten this phase of the customer journey and move the customer closer to the purchase stage.

Reliable needs assessment and the resulting personalization also helps retailers cater to and follow up on customers' needs. Retailers' enhanced, technology-based ability to offer more personalized experiences for each customer—including product design, recommendations, information, and even pricing and promotions—also increases the likelihood that a consumer will become vested in the product during the pre-purchase phase, such as when they participate in designing it, which also gets them closer to the purchase phase. For example, customers who design their own Nike sneakers might not be able to resist buying their own creation; similarly, LL Bean encourages customers to design backpacks that meet their precise needs. The technologies that enable such personalization not only pertain to design but also to manufacturing, such as 3D printing, just-in-time production, or demand flow technologies.

Even if the customer does not formally design the product, retailers can personalize other features, such as information or promotions, to match customer needs. Consider a group of tourists trying to book a flight to Egypt. When they search for flights online, they expect to see banner ads for various hotels and tourist destinations in Egypt. But if they sort the flight options differently, such as by price, shortest route, or airline brand, AI-enabled technologies can identify them as price sensitive, convenience oriented, or brand loyal, respectively. The subsequent offers to these cohorts of customers should feature a lower price, alternative route options to cut the time spent traveling, or stops made by the same airline at other regional destinations. The ability to modify information on websites, according to how the consumer searches, also has been called web morphing.

Search engagement technology

Once needs have been recognized, customers can search, evaluate alternatives, and engage with the brands. This substage is particularly important from a retailing/marketing viewpoint, and many technologies aim to help retailers provide the right information in the right place at the right time, as well as engage customers to encourage them to purchase. Showrooms that feature augmented reality (AR) and virtual reality (VR) technologies enable customers to assess the suitability of a product, while also engaging and entertaining them. Similar to our discussion of AI and ML, we note that AR and VR often are confused or used interchangeably, despite their differences. First, AR augments reality, by superimposing digital elements onto another object (e.g., jewelry on a person's neck, new furniture in a living room) without requiring those objects to be in physical proximity. Several mobile apps linked to cameras, such as the Virtual Artist app by Sephora, can create personalized AR experiences. Second, VR creates and provides an immersive experience for users, which might be totally separate from reality, like virtually flying through the clouds, swimming away from a shark, or hiking Machu Pichu. Holographic lenses and 3D glasses support VR experiences. In addition, AR and VR can be combined to create mixed reality (MR), which might allow users to feel like they are hiking Machu Pichu and also insert a representation of them into that setting, so it looks as if they were there. Together, all these types of realities are called extended realities (XR).

By providing appropriate information in the pre-purchase stage, retailers also might steer consumers toward their brand

or retail outlet, perhaps by installing suitable technologies to respond promptly to consumer queries or digital kiosks to provide voluminous information that customers can search easily. Virtual store assistants such as chatbots generally facilitate online searches; robotic store assistants help answer queries in stores. Physical retailers seemingly are moving toward automated retail frontlines, with robots in sales and service roles to help customers by providing price, location, or product availability information. These tools ensure the consumer can purchase the item, once they enter the next purchase stage.

Retail Technologies for the Purchase Stage of the Customer Journey

Once the customer has made the decision to purchase a product or service, the non-physical (documentation) part of completing the transaction includes agreeing to buy and making the payment, and the physical part entails acquiring the product or service. Technology can help facilitate both stages.

Purchase transaction technology

Consummating a purchase requires the offering to be available in inventory for sale. Historically, brick-and-mortar stores and warehouses have relied on physical checks, conducted by human employees, to ensure a product is available for the customer to purchase, but technological tools, such as RFID, scanners, inventory robots, and cloud computing, already have demonstrated their ability to provide more efficient and detailed stocking, ordering, checkout, delivery, and inventory monitoring activities. Cloud computing, which grants retailers real-time access to operational and financial data across their omnichannel operations, is a key element. Its related solutions are widespread in back-end supply chain logistics and stock replenishment efforts, but cloud computing also is moving to the front-end interaction between frontline sales personnel and customers, offering real-time analyses of inventory or general product availability information. Thus frontline employees can avoid disappointing customers, because even if a desired product is out of stock at a current location, they can find where it is available and perhaps help customers place an online order, which implies a sort of endless aisle experience.

Many companies also consider headless commerce—a scenario in which the presentation layer (e.g., website) is decoupled from the ecommerce platform, even though customers still can easily click a "Buy Now" button or issue a verbal command to a voice-activation device such as Alexa to order a product. By decoupling the front- and back-ends though, advanced technology increases retailers' flexibility, such that they can focus on more relevant user experiences in the front end while prioritizing efficiency and consistency in the back end to enhance fulfillment speed.

Moving on to the payment step, we note extensive shifts from cash-based toward card-based payments. Even among card-based payments, we have moved from swipes of credit cards to insertions of chip-embedded cards to taps with credit cards to touchless options. Even further, technology allows for cashless and digital payment through e-wallets (e.g., Apple

Pay, Samsung). We anticipate growing uses of crypto currency too, leveraging Bitcoin or blockchain recorded payment systems for retail transactions. Amazon even is experimenting with how to link payment information to people's physical hands; technology-enabled shoppers would simply wave their hand at a checkout terminal, have it read their palm, and complete the payment. Social media platforms are developing more convenient ways to load payment information too, to expedite easy, frictionless shopping processes, and their success likely will be a critical determinant of their expanded retail presence.

As another way to reduce purchase friction, retailers have gone beyond offering self-checkout counters to developing smart shopping carts and other AI-enabled tools for recording purchases. Smart shopping carts allow customers to gather items, scan them automatically, and pay for their purchases, without any further interaction, as exemplified by the SmartCart available in Amazon Go. In this version, customers place items in the cart, which scans the goods using AI-based cameras and applies the charges to the customer's Amazon account. Online retailers are also relying more on in-home tools like Alexa to make it easier for shoppers to state their desires out loud and complete the purchase that way.

Physical acquisition technology

When it comes to receiving the purchased product or service, customers expect to get the right product. This expectation has not changed much over time; regardless of technology advances, people want to obtain what they agreed on in making the purchase transaction. They also expect to receive it at the right time, and this expectation has shifted, such that customers expect expedited delivery for nearly every purchase. Technology enables same-day delivery, as offered by Amazon Prime, mainly by enhancing back-end supply chain and logistics efforts. But at the customer interface, emerging tools such as drone delivery and lockbox storage for perishables help customers receive their purchases when, how, and where they want them.

Retail Technologies for the Post-Purchase Stage of Customer Journey

The customer journey does not end with a purchase. Retailers should continue to engage with customers through their websites, brand communities, and social media, as well as provide follow-up service and work to retain them. Technology enables all these goals.

Follow-up service technology

Follow-up service might involve ordering additional parts or requesting services after the purchase. In addition to the consumer recognizing such needs, AI- and IoT-enabled appliances (e.g., washing machines, refrigerators, cars) can identify those needs too and even bypass the consumer in the purchase stage. Retailers should develop systems that allow AI- and IoT-enabled machines to order replacement products, request services, and schedule deliveries from the retailer directly.

Follow-up services also relate to product returns, and in this effort, data analytics technology is critical. Companies such as

The Retail Equation work with retailers to develop a "risk score," based on a customer's shopping and return history data, that indicates whether returns should be accepted or denied. Similarly, Amazon's proprietary data analysis methods identify accounts with excessive returns; if necessary, it will even ban those users. Technology can also reduce the need for returns in the first place: AR, online chatbots, and technology-facilitated in-store assistants all help customers find the right style, fit, or solution prior to making their purchase, so they are less likely to need to return items (Robertson, Hamilton, and Jap 2020). When they do though, digitally and physically connected retail technology makes it easier, because it lets customers return a product purchased online, such as from Amazon, to a physical location, such as a Kohl's store, or else through the mail.

Loyalty management technology

After a purchase, a retailer wants to retain the customer, to increase his or her lifetime value. Rewards programs have been in vogue for decades as a means to increase retention, but integrating these programs with mobile app technologies has greatly increased the flexibility and control that customers have for managing the rewards, with positive implications for their propensity to stay loyal.

Another possibility involves the use of blockchain technology, which links blocks of information chronologically in an immutable chain to establish greater data permanency, safety, trust, and transparency. It provides a sort of digital version of an old ledger book, preserved for eternity. Considering the retail industry's struggles with customer data safety, regulations, payment security, and opaque supply chains, blockchain technology offers great promise. Although its use remains quite new, some applications already have shown how capturing the activities of frequent flyer customers in the travel industry can enhance their loyalty.

Research Directions

As the previous sections reveal, since 2000, growing numbers of customer-interfacing retail technologies have emerged, improving retail customer experiences and moving customers through their omnichannel journeys. The speed with which customers adopt these emerging technologies continues to increase, perhaps partially due to the COVID-19 pandemic that requires social distancing and has limited their access to physical stores. In this dynamic, rapidly changing environment, we reflect on where retail technology might go in coming years, as well as some related opportunities for research.

As the Greek philosopher Heraclitus said, "The only constant in life is change." And as the rock musician Randy Bachman would add, "You ain't seen nothing yet!" Technology in retail has been and will continue to change, rapidly and in unfathomable ways. When developments occur so quickly, there may be a tendency to lose direction, sense of purpose, or a feeling of control. Therefore, it is up to academia to help guide the evolution of retail technology to encourage its effective, safe, and appropriate application. We propose ten key areas for research, as listed in Table 2.

The Impact of COVID-19

Although technologies already were changing rapidly, the COVID-19 pandemic has accelerated the pace to breakneck speeds. Faced with lockdowns and other restrictions, consumers demand options to make purchases from home. This lifestyle change has altered customers' purchase journey and their uses of retail technology. In this sense, retailing is among the most impacted business sectors, as demonstrated by retail bankruptcies and substantive changes in retail strategies (Roggeveen and Sethuraman 2020). The effects of the pandemic also appear likely to persist and may herald a "new normal," including a less elaborate need assessment phase that focuses on fewer needs, such as those related to product safety and functionality, reliability, price, availability through home delivery or curbside pickup, fast delivery, and the ability to consume the products at home. In response, retailer technology tools that allow customers to place orders from their mobile phone, assign them codes they can use to track their order delivery status, and support expanded curbside pickup options, along with touchless production and delivery are becoming more popular. For example, Amazon Prime is actively promoting and providing same-day delivery. Domino's markets its touchless pizza delivery to emphasize safety. With chatbots and other devices, grocers show shoppers private-label options and provide related information, such as recipes. Even Tesla, which most pundits predicted would struggle to sell its high-touch, luxury electric cars, has introduced a touchless car delivery system, together with advanced online search, engagement, and sales tools, such that its revenues and stock value nearly tripled during the pandemic (Higgins 2020).

Consumers' digital devices also facilitate both pre-purchase and purchase phases of the customer journey during the COVID crisis, suggesting the need for all retail technologies be compatible with mobile presentations. Retailers might enhance their websites and apps to enable more virtual showrooms that help customers experience products—not just clothing and jewelry but also bigger ticket items such as home furnishings—without leaving their homes. For consumers whose disposable income has not been significantly disrupted by the crisis, retailers need to facilitate larger and risky purchases, such as home furnishings or renovations, without relying on traditional high-touch interactions. An extended version of search technologies features livestream channels through store apps, like a mobile, retailer-specific version of the Home Shopping Network. While customers watch from home, a salesperson can provide a tour of products available, according to the customers' needs.

During the purchase stage, customers still want quick checkout and reliable, fast, safe delivery. For routine online purchases, such as groceries, customers prefer convenience, such as completing the transaction with fewer clicks, suggesting the need for retailers to provide one-click option. With regard to delivery, automated curbside access is increasingly popular, and at-home drone or drone–van combination deliveries may be viable quite soon.

Table 2
Customer interfacing retail technologies: future research directions.

#	Research area	Key research questions
1	Impact of COVID-19	• How have consumer expectations and behavior changed, and how will they change during the pandemic, especially with respect to use of retail technology? • What technologies should retailers invest in for the short-term and long-term, in response to the pandemic?
2	Measuring returns from retail technology	• What factors prompt the introduction of new technologies, and which new technologies should be introduced? • How should technologies be marketed? • How can retailers measure the returns on their technology initiatives?
3	Identifying collaborative opportunities	• How much data should retailers share with their partners for mutual benefit? • How can they choose collaboration partners and what types of collaborations to undertake?
4	Vertical integration	• How can retailers identify collaboration or integration opportunities? • Which partners are appropriate for collaboration or integration efforts?
5	Organizing for technology	• How should a firm reorganize to leverage technology? • What new departments or divisions should be introduced?
6	Data privacy	• What data are consumers willing to share? • What benefits do consumers expect in return from sharing their data?
7	Retail technology for circular markets	• What products are conducive to a circular economy or gently used market? • How should such products be marketed?
8	Technology for social media platforms	• Will adding an e-commerce layer to social media platforms hurt or benefit the platforms in the long run? • Do consumers consider purchase options an added benefit or a distraction? • What products should be sold through social media platforms?
9	Retail technology and private labels	• What type of platforms are most effective for private-label marketing? • Are influencers good private brand ambassadors? • What are the potential dark sides of social media campaigns and technology tools for brands with different value propositions? • What returns on technology investments can private labels attain?
10	Technology globalization	• What factors influence technology adoptions globally? • How should retailers standardize or adapt technology in different regions?

As the gravity and longevity of the COVID-19 pandemic continue to increase, its powerful impact on consumer expectations and retailer activities continues to grow too. Technology has and will continue to have a pivotal role, so to help retailers cope with the difficult situation, researchers might address questions such as: How have consumer expectations and behaviors changed? How will they continue to change as the pandemic persists, especially with respect to use of retail technology? What technologies should retailers invest in, for the short- and long-term, to address and leverage these changes?

Understanding and Measuring Returns from Retail Technology

Retailers often get excited about a new technology, without a clear realization of whether its adoption makes business sense. Others might use certain technologies only because their competitors use them. But before making significant fixed investments in retail technologies, they should understand the purpose for the tool and perform an analysis to predict the likely monetary benefits. More research is needed regarding which factors prompt new technology introductions, which new technologies are needed, how they should be marketed to consumers, and how to measure the returns on technology initiatives.

Identifying Collaborative Opportunities

Due to increasing technology sophistication, no single company, even one as vast as Amazon or Google, can go it alone, without the help and cooperation of suppliers, other retailers, and end-users. Retail technology results from and also facilitates such collaborative efforts. For example, Kellogg and Tesco are sharing data to identify purchase patterns; Apple is working with Reliance Retail in India to develop special offers; Paytm lists multiple offline electronic stores on its online platform; and Walmart and Google are collaborating on voice-controlled shopping capabilities. Researchers should define the nature and extent of such collaborations, as well as determine how much

data retailers should share with manufacturers to ensure their mutual benefit.

Vertical Integration

In this extreme form of collaboration, companies combine, through acquisition or merger, and thus link their competencies. Many digital retailers are actively seeking ownership of retail technology firms, app developers, software companies, and drone manufacturers, as well as transportation and delivery service providers. Innovative startup companies often need cash to sustain and grow their operations, so retailers with deep pockets can acquire them and, ideally, create synergies. For example, during the pandemic, Apple acquired both Voysis, an AI startup that specializes in digital voice assistants, and NextVR, which provides VR tools for sports and entertainment programs. Around the same time, Uber acquired its downstream partner and rival Postmates for $2.65 billion in stock. Yet these companies previously has different impacts on customers' journeys, which may be part of the rationale for the acquisitions. Research is needed to establish how retailers can decide which companies to collaborate with or acquire. In that regard, our proposed customer journey framework might help guide strategic integration and collaboration efforts, according to retail technology classifications. For example, a company with more expertise in pre-purchase technology might scout for firms with capabilities in purchase or post-purchase technologies.

Organizing for Technology

To cope with the complexity of retail technology, some retailers have established dedicated departments that are tasked with defining the behavioral patterns of "nextgen" consumers. Such insights often come from social media, using text mining of blogs, Twitter, and Facebook or image content analysis of Instagram. In addition to understanding customers and their uses of technology, firms should organize themselves according to insights into the optimal retail organizational structure in a digital world. For example, at Friday's restaurant, the IT department reports to the chief experience officer, but such structures might need to change as takeout becomes the dominant mode of consumption, rather than on-site dining.

Data Privacy

Most recent retail technology provides means to collect, analyze, and leverage data in digital, audio, and visual forms, which in turn make data privacy issues paramount. If retailers collect and track vast amounts of customer information to support their personalization efforts, they also raise data privacy concerns. In a viral example, Target predicted a customer's pregnancy based on her browsing data and sent related products to her home, even before she had shared the information with her family (Hill 2012). It is the responsibility of retailers to be cognizant of and address privacy concerns, perhaps even beyond governmental regulations. The General Data Protection Regulation (GDRP), enacted in the European Union in 2018, and the California Consumer Privacy Act, enacted in 2020, require retailers to inform customers explicitly about which data they are collecting. Consumers might agree to such data collections, but they also might demand benefits in return, such as more relevant, personalized experiences. Continued research is needed to ascertain which data consumers are willing to share and what they expect in return.

Retail Technology for Circular Markets

Other changes to retail systems might result from a different impetus but be enabled only once the supportive technology is available. For example, increased sustainability consciousness has led consumers to seek out more circular markets and generated active demand for gently used and recycled goods. Although second-hand markets have long existed, it was not until technology-enabled companies like Rent-the-Runway (clothing) or Fernish and Feather (furniture) established vast, scalable operations that they could grow to a global scale. Second-hand, technology-enabled markets for goods also may grow substantially in coming years, thanks to technology; more research on this relatively poorly understood context would be welcome.

Technology for Social Media Platforms

Social media platforms facilitate information exchanges, mainly during the pre-purchase stage but also potentially in the post-purchase phase. As online shopping rates have increased recently, these platforms also are expanding to include e-commerce (search, order taking, payment) capabilities, often in collaboration with major retailers. When Instagram debuted its checkout feature in March 2019, about twenty brands, including Adidas and Nike, enrolled; Target soon followed suit. Consumers thus can tap on a product, choose a size and color, and proceed to checkout. But adding an e-commerce function to social media platforms arguably could harm the platform, if consumers prefer to avoid purchase-related information in this hedonic, social setting. Will consumers consider purchase buttons an added benefit or a distraction? Furthermore, which products might be most conducive for sales through social media platforms?

Retail Technology and Private Labels

Retailers enjoy tremendous scope for leveraging technology to promote their private labels, because they can influence every stage of the purchase journey to direct people toward the purchase of these offerings. In the pre-purchase needs management stage, they can collect customer data and then ensure their private-label offerings match their needs better than a national brand. In the search stage, they can work with social media platforms to inform, promote, and sell their products, as Albertson's grocery chain has done on Pinterest. In the purchase stage, Amazon might program Alexa voice assistants to place orders for its own branded products. In essence, technology has the potential to digitize store brands, though clearly this influence could quickly become excessive and lead to misuse or abuse.

When promoting private labels, which types of platforms are most effective? Can influencers be effective private-label brand ambassadors? What potential dark sides might arise from social media campaigns or the use of technological tools for brands that offer different value-based propositions?

Technology Globalization

Technology is an evolving, inevitable, global phenomenon, essential for firms' survival in competitive markets but also viable as a means to enhance customer service and consumer welfare. However, different countries and regions of the world adopt technologies at different times and in different ways, depending on their technology infrastructure, consumer culture, economic climate, and competitive atmosphere. Research can help guide adaptations of retail technology to global arenas. For example, the same-day delivery offered by Amazon in the United States may not be feasible or desirable in India.

In summary, the world of retailing is changing rapidly, and much of that change has been enabled by customer-interfacing retail technologies. We offer a framework for classifying technologies, based on their primary influence on a customer's purchase journey. It is critical that practitioners and academics collaborate to conduct further research into appropriate uses of retail technology to create win–win situations for retailers and consumers.

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