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Leveraging in-store technology and AI: Increasing customer and employee efficiency and enhancing their experiences

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Leveraging In-Store Technology and AI: Increasing Customer and Employee Efficiency and Enhancing their Experiences

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Abstract

Due to digital innovations, retailing is undergoing radical changes. Scholars have proposed frameworks to address outcomes of implementing technology e.g., an increased customer experience, efficiency gains, consumer or employee acceptance. Existing frameworks concentrate primarily on the consumer perspective, focus on specific technologies (e.g., AI) and covering the customer journey. In contrast, this paper also focuses on the employee perspective, and how technology influences the employee journey. Since the convenience offered by online retailers puts offline retailers under pressure, this research focuses on in-store technology. Based on a comprehensive review of managerial and academic literature and expert interviews, we propose a framework covering customers and employees, and technology's function (increasing efficiency or experience), as also including more traditional and newer technologies, such as robots and AI. We identify and showcase technologies increasing efficiency for customers (quadrant 1, e.g., checkout options or autonomous stores) or for employees (quadrant 2, e.g., in-store robots), and enhancing the experience for customers (quadrant 3, e.g., retailer apps or communication) or for employees (quadrant 4, e.g., exoskeletons or smart wearables). Finally, for each of these quadrants, we identify future research opportunities.

Keywords: In-store technology; AI; Retail employees; In-store; Retail strategy; Efficiency; Enhancements.

The retail industry is undergoing radical changes and unprecedented transformations due to digital innovations. Over the last decade or so, the advent of a variety of technologies, data analytic capabilities, and the emergence of various forms of artificial intelligence (AI) have made tremendous inroads in the retail and service industry (Shankar et al. 2021). These technologies have influenced both online retailing and in-store retailing. The current focus of the paper is on an understanding of the role of in-store technology and AI (in all forms e.g., robots). In a recent paper, Grewal et al. (2020, p. 96), highlight that "we are amid a technological retail revolution. There are an increasing number of technologies available to retailers and service providers that have the potential to enhance both their operations and the experience they can provide customers."

The current retail landscape is filled with examples of how different retailers and service providers are experimenting and using a variety of retail technologies in their stores, such as smart screens, self-checkout counters, apps, robots, and the list goes on. For example, robots are being deployed in stores and service setting to perform a host of services, such as cleaning stores, scanning prices, answering customer queries, tracking inventory, and carrying merchandise.

A simple dichotomy between technology-supported channels and offline retailing is insufficient today. Instead, retailers

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must devise careful omnichannel strategies that account for the role of continually evolving in-store technologies and use of AI, and customers' and employees' acceptance of retail technologies. Such complex requirements have prompted the development of several useful retail technology frameworks and typologies, based on distinct perspectives, which we summarize in Table 1 according to some of the key elements they contain and the implications for our current research.

In terms of the *main beneficiary,* most existing retail technology frameworks focus on customer-facing technologies (Grewal et al. 2020; Inman and Nikolova 2017, Roggeveen and Sethuraman 2020) and take a customer journey perspective, often divided into stages (e.g., prepurchase, purchase, post-purchase) (Hoyer et al. 2020; Roggeveen and Sethuraman 2020). Grewal et al. (2020) prioritize the purchase phase in a typology focused on in-store technology. A few other efforts include stakeholders beyond customers into technology frameworks, such as suppliers (Guha et al. 2021), employees, or both (Shankar et al. 2021). In addition, in this paper, we focus on the employee journey associated with using technology and - for simplicity - note three stages of this journey: training, application for internal store operations, and helping assist customers.

Regarding the *unit of analysis* and *focus*, many frameworks address the technology itself according to its vertical depth or intelligence (Davenport et al. 2020), as well as the horizontal breadth offered by different technologies. Some studies are restricted to certain technologies or technology clusters (Hoyer et al. 2020), AI-enabled technologies (Davenport et al. 2020; Guha et al. 2021), or robots (van Doorn et al. 2017), in retailing and service contexts. A few efforts that attempt to be all-encompassing span the breadth and depth of retail technologies (Grewal et al. 2020; Inman and Nikolova 2017). The majority of these studies do not focus on in-stores technologies (for an exception see Grewal et al. 2020), yet in-store technologies are critical in assisting both customers' and employees' journeys. In this manuscript we focus on *all in-store technologies*, both AI-enabled and not.

Over and above the unit of analysis, focus, and the main beneficiary, existing frameworks also use various other criteria, amongst them the *function of the technology*. Sethuraman and Parasuraman (2005) differentiate cost-saving and service-enhancing technologies; Gauri et al. (2021) claim that offers of greater convenience or experience provide potential paths for retailers to remain competitive. Grewal et al. (2020) categorize technology according to increasing convenience and/or social presence, van Doorn et al. (2017) address automated versus human social presence, and Hoyer et al. (2020) cite the experiential value components of the customer experience (cognitive, sensory/emotional and social). In this manuscript, we focus on both the efficiency and experience gains for customers versus employees.

We take inspiration from, and seek to complement, these frameworks as noted previously. To summarize our contributions, first, most frameworks concentrate on customers as the main beneficiaries of technologies; to understand their implications more broadly, we expand the relevant set of beneficiaries to include both customers and employees. Second, along with providing detailed insights into emerging, intelligent technologies, we review existing, more traditional technologies to ensure that our comprehensive framework is informative for various retailers, at different stages of the technology adoption journey. Third, noting that offline retailing comes under tremendous pressure from the increasing market share and convenience offered by online retailers (Gauri et al. 2020), often leading these retailers to implement digital components in their stores (Jindal et al. 2021), we focus on in-store technology. In so doing, we focus on the main function of the technology, namely, either to increase efficiency, beyond just saving costs, to include saving effort or time as well, or to be enhance the experience of either customers or employees. Thus, these technologies have important implications for both customer journey management and retail employee journey management.

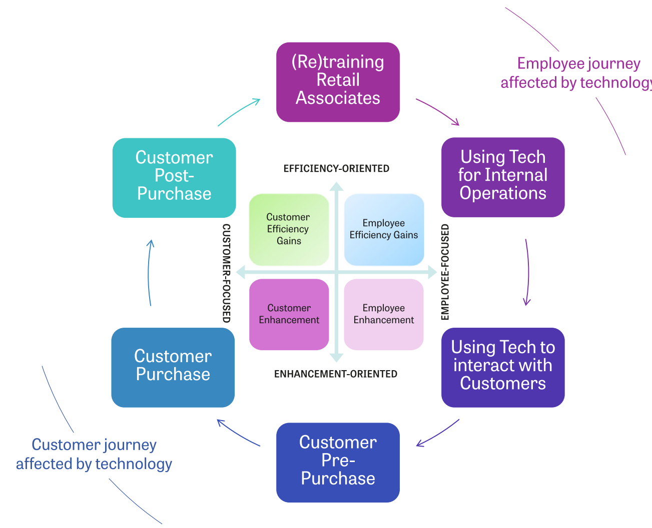

Fig. 1. Retail Tech and Retail Associate & Customer Journey Management Framework.
Note: It must be noted that the stakeholders are depicted as customer-focused or employee-focused, but technologies can also be both customer and employee focused. In a similar vein, the outcome of the technology is depicted as efficiency-oriented or enhancement-oriented, but the outcome could be both.

Conceptual foundation

Various in-store technologies can influence customer and employee efficiencies and enhance their experiences. Therefore, these in-store technologies can have a vital role in improving *both* customer and employee journeys. We discuss how technology can influence these journeys below (see Fig. 1). This overarching framework highlights: (1) an abbreviated three stages of customer journey management, (2) abbreviated three stages of employee journey management, and (3) four quadrants of in-store technologies organized based on the beneficiary of the technology (customer or employee) and

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Table 1
Summary of Previous Frameworks.

Citation	Main beneficiary of the technology	Unit of Analysis	Focus: In-store? Yes/No	Function of the Technology	Framework foundation
Grewal et al. (2020)	Customers	All technologies	yes	Technologies' levels of **convenience** & **social presence**	conceptual & qualitative data
Guha et al. (2021)	Customers	Artificially intelligent technologies	no	**Customer facing** versus non-customer facing **technologies** and boundary conditions, application value, online versus in-store and ethics concerns	conceptual & qualitative data
Hoyer et al. (2020)	Customers	Emerging technologies, IoT, AR/ VR/ MR, virtual assistants/ chatbots/ robots	no	Presence of technology in **customer journey stages**, pre-transaction, transaction, post-transaction **Customer experience dimensions** with technology: cognitive, sensory/emotional, social	conceptual
Inman and Nikolova (2017)	Customers	All technologies	no	Levels of **privacy concerns** & positive **attitude** towards technology	conceptual & quantitative data
Noble et al. (2022)	Set of stakeholders, customers, employees, companies & society	All technologies	no	Levels of technological & human **strengths**	conceptual
Roggeveen and Sethuraman (2020)	Set of stakeholders, customers, employees, companies & society	All technologies	no	Presence of technology **customer journey stages**, pre-purchase, purchase, post-purchase, various technology nodes within the stages, e.g., needs management and search engagement in the pre-purchase stage	conceptual
Shankar et al. (2021)	Customers and Employees	All technologies	no	**Customer journey stages**, pre-purchase, purchase, post-purchase, various technology nodes, e.g., needs management and search engagement	conceptual
The framework in this paper	**Customers and Employees**	**All technologies**	**yes**	**Efficiency versus experience gains for customers versus employees**	**conceptual & qualitative data**

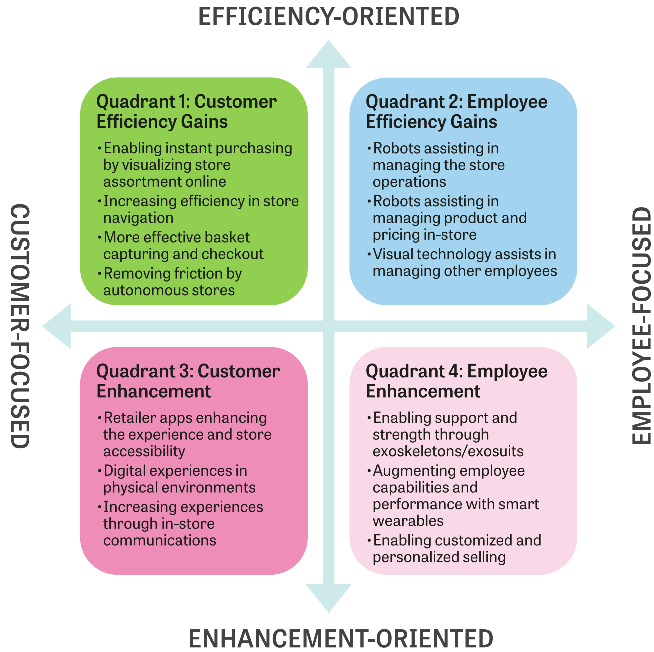

Fig. 2. The Four Quadrants.
Note: It must be noted that the stakeholders are depicted as customer-focused or employee-focused, but technologies can also be both customer and employee focused.In a similar vein, the outcome of the technology is depicted as efficiency-oriented or enhancement-oriented, but the outcome could be both.

outcome of the technology (increasing efficiency or enhancing experience).

As Fig. 1 reveals, technology is likely to influence all steps of the *employee journey*. We outline three steps of the employee journey associated with using technology: training, application for internal store operations, and interacting with customers. Although in this paper we do not address the ease or difficulty of training retail associates to use various technologies in effective, relevant ways, this question is important, because the ultimate success or failure of a technology and its diffusions depends on whether users understand its functional attributes and feel comfortable using it to supplement their own efforts. Technology can used to help retail employees with internal store operations (i.e., increase efficiency), such as cleaning the store, restocking, changing prices and promotions. Additionally, technology can aid retail associates with their interactions with customers (i.e., enhance experiences).

In contrast to the employee journey, *the customer journey* involves "understanding and managing customers' experiences throughout their shopping journey" (Roggeveen and Grewal 2020, p. 3), which consists of prepurchase, purchase, and post-purchase stages (Fig. 1). The various in-store technologies that are discussed in this paper can help customers be more efficient and/or can enhance their experiences. For example, these technologies can help customers in the prepurchase stage considerations by improving their in-store search capability, allowing them to better understand options, helping them make decisions, and understand the benefits that they will receive from a given item. All these aspects improve the customer's pre-purchase journey. Improving their search, evaluating options, speeding up their choices, all aid in making their pre-purchase stage more efficient, and more details will be discussed as we outline the four quadrants. Helping them understand benefits and even better understanding their needs are aspects of the pre-purchase customer journey where technology can enhance customer experiences. Technology ranging from autonomous stores (e.g., shopping at an Amazon Go store) to mobile payments assist the customer during the purchase stage of their customer journey. These technology elements aid the consumer to purchase the needed products and services more efficiently, as well as assisting them pay for the merchandise. Technologies can also aid consumers in the post-purchase stage such as providing access to customer service agents and return options using mobile apps, as well as sharing information with others about their purchase (e.g., reviews, word of mouth).

More details on customer journey management can be found in Grewal and Roggeveen (2020) and Roggeveen et al. (2020). Furthermore, interested researchers should examine the rich work in the domain of shopper marketing. Shankar et al. (2011, p. S29) define shopper marketing as "the planning and execution of all marketing activities that influence a shopper along, and beyond, the entire path-to-purchase, from the point at which the motivation to shop first emerges through to purchase, consumption, repurchase, and recommendation."

In-Store Technology: Four-Quadrants

We now turn our attention to the 2×2 typology in the center of Fig. 1. We consider two dimensions of in-store technologies that reflect our review of prior research: 1) whether the stakeholder being targeted by the technology is the customer or the employee, and 2) whether the technology primarily aims for greater efficiency or enhancing experiences (i.e., outcome of technology). We outline the four-quadrants (Fig. 2) to define the roles of in-store technologies in supporting retailers' efforts.[1] For each quadrant, we identify several exemplar technologies and their roles, based on interviews with key informants in the retail sector. These eleven interviews are briefly outlined in the Appendix.

First, retailers can leverage technology including robots and AI that focus on either customer-facing applications (e.g., recommendations, personalization, in-store customer experience management) or supply-side operations that are not customer facing (e.g., inventory optimization, logistics, in-store efficiency) (Shankar 2018). Building on frameworks introduced by Guha et al. (2021) and Guha and Grewal (2022), we distinguish in-store technologies that are mainly customer

[1] We have limited out framework to four-quadrant to increase the ease of its exposition. However, it could be further be developed into a 3x3 framework by explicitly discussing how in-store technology can increase *both* efficiency and enhance experiences, while also including *both* customer and employee focus (rather than individually).

facing[2] and those that indicate an employee focus (i.e., non–customer-facing).

Second, retail success can come from efficiency gains and/or customer experience enhancement, such that "companies that embrace the opportunities and experiment with the technologies, to determine which technologies best enhance operational efficiency and which best enhance the customer experience, are likely to be the most successful" (Grewal et al. 2020, p. 96; see also Gauri et al. 2021). Increasing efficiency entails that retailers reduce or remove any friction, effort, inconvenience, obstacles, or "pain points," such as by reducing wait times, or unnecessary steps (Brynjolfsson and Smith 2000; Gauri et al. 2021). Essentially efficiency gains are defined as adding value by reducing the sacrifice or the cost component rather than the benefit component of the value of an experience (Zeithaml, 1988). Removing friction and increasing convenience can facilitate cost savings for the customer and the retailer, along with other positive outcomes such as satisfaction (Benoit et al. 2017). By also including effort or waiting time into the framework, we extend beyond an exclusive focus on cost-saving technologies (Sethuraman and Parasuraman 2005). Therefore, we extend prior literature (Gauri et al. 2021) by incorporating technologies that remove friction, save costs, and thus increase efficiency for customers and employees.

Whereas efficiency gains result from *removing* friction, technology can enhance experiences by *adding* something positive to them. Enhancing experiences means increasing the benefit component of value (Zeithaml, 1988), which can be achieved for instance through making encounters more vivid or interactive or augmenting physical capabilities. For instance, Shankar et al. (2021) describe how technology that uses virtual or augmented reality can augment experiences with greater vividness, immersion, and interactivity. Grewal et al. (2020, p. 96) note how technologies with social presence also increase consumers' involvement, sense of imagery, and elaboration. Such technology-enabled augmentation thus offers novel value for consumers (Hoyer et al. 2020), rather than just speeding up processes or helping customers find items (Sethuraman and Parasuraman 2005).

By addressing how technologies remove friction (enhanced efficiency) and add to the experience (enhanced experience), we establish clear, managerially relevant criteria, while also acknowledging their potential overlap. Technology that removes friction might enhance experiences too. The quadrants of our framework represent the *main* function and target of the technology, but they are connected. For instance, efficiency gains for employees (e.g., them being able to communicate quicker) often indirectly affects customers and how quickly the employees can serve them. Or in line with the service profit chain (Hogreve et al. 2017) enhancing employees usually spills over to customers also enhances their experience. For the purposes of this study though, our framework pertains to a direct (not derived), core function of each technology. We believe that - for managers - it is valuable to consider the main function and the main target audience of a technology, rather than staying vague on this.

Quadrant 1: Efficiency Gains for Customers

Online shops enable instant purchases from a broad and accessible assortment, removing the friction that customers encounter in physical stores when they seek to fulfill their immediate needs but cannot find items or face limited availability. In online shopping consumers encounter friction in that they must wait for the delivery. To overcome these frictions, consumers often engage in shopping processes that span across online and offline channels (Kahn, Inman, and Verhoef 2018), sparking the need for omnichannel retailing (Verhoef, Kannan, and Inman 2015). For example, by showrooming (gathering information offline, purchasing online; Gensler et al. 2017) or webrooming (search online, purchasing offline; Flavián et al. 2019) customers often switch providers. To encourage customers to remain in their ecosystem, retailers offer customers options for buying online and picking up in-store (BOPIS, Gauri et al. 2021).

In continued efforts to bridge the gap between online and offline channels (Shotwell 2022), emerging retail technology offers SOPIS (search online, purchase in-store) options. Currently, BOPIS and SOPIS takes place mainly within a single ecosystem, as when IKEA customers purchase online and pick-up in store or determine the availability of certain items in their local store before visiting to make the purchase. As a next step, third party providers started enabling SOPIS across providers, so that online searches for products not only reveal various online stores with availability, but also show product availability at nearby retailers, based on real-time assortment information of physical stores. Providers like NearSt (www.near.st) and Pointy (pointy.withgoogle.com) *present store assortments of physical stores online* as a result of a nearby online search. Currently, the availability of these services remains patchy, and they often are ineffective (e.g., showing a retailer many miles away). Nevertheless, we anticipate its growth, due to its ability to reduce a major consumption friction (e.g., waiting time for delivery of an online purchase), which would be a gamechanger for physical retail stores.

Second, technology can *increase the efficiency of in-store communication* by removing frictions related to searching for information or in-store staff. This is important as - for customers - waiting for in-store services is a major "pain point" (Kahn 2018). Currently retailers offer *in-store kiosks* or *smart shelves* to provide additional information about products (Grewal et al. 2020). We anticipate that retailers will increase the breadths of information and the interactivity of these tech-

[2] The "customer facing" concept is a continuum (Guha et al. 2021; Guha and Grewal 2022), such that activities that involve directly interfacing with customers in store are customer facing, activities like cleaning the retail store after hours are not customer facing, and activities like turning on a cleaning robot that cleans during store hours and avoids any direct interaction with in-store customers falls somewhere in between "customer facing" and "non–customer facing." In this paper, while here we primarily discuss employee initiatives, more generally we mean non-customer facing initiatives.

nologies to help customers save time and effort while shopping. Efficiency gains for employees, which will be covered in the next section, often indirectly affect customers. For instance, headsets allow employees to communicate more efficiently and with this serve customers quicker.

Third, particularly in stores with large footprints, technologies can *increase the efficiency of in-store navigation* by providing easy-to-follow maps or instructions that provide search convenience comparable to that offered by online retailers (Dekimpe et al. 2020). Traditionally, *in-store kiosks* have provided directions to specific providers or products, but they are limited in their ability to reduce friction, due to their non-portability, meaning that customers must memorize the directions.

In the future, retailers seem likely to adopt portable versions of such in-store navigation services, and in so doing, they should recognize that customers often prefer to interact with their mobile devices rather than a salesperson (Kahn 2018). Already, portable technologies have been added to shopping carts, such as by Carrefour (Roggeveen and Sethuraman 2020); integrated into in-store robots, such as by Lowe's (Davenport et al. 2020); included in retailer apps, such as by Kroger (Dekimpe et al. 2020); and combined with hardware in stores, such as electronic shelf edge labels (ESLs), as by Monoprix, where customers' phone apps determine their location and cause ESLs to start flashing when they approach (Berg 2022). In-store navigation also might be connected with other services, for example, customers' shopping list automatically get sorted according to the placement of their chosen products in the store, allowing for highly efficient navigation around the store. The CEO of the firm (doing the above) shared in the interview that one-function apps are not future proof since in his view the app needs to combine different functions and shopper missions (see Appendix – Interview 11). Finally, a technology firm (see Appendix – Interview 1), has developed a generative AI powered app that not only helps shoppers find items in a retail store, but also suggests complementary items to shoppers. This app thus not only saves the shopper time, but also enhances the shopping experience, and all this has led to a sales lift in such app trials.

Fourth, the checkout is almost invariably regarded as friction, specifically, waiting in line is the most commonly mentioned friction in physical stores, noted by more than 75% of customers (Kahn 2018). Hence, retailers have experimented with both traditional and emerging technologies to *increase the efficiency of basket capturing and checkouts.* Self-checkout options might reduce waiting time for a staff member and increase autonomy (Benoit, Altrichter, and Grewal 2023), but increases the effort required for customers. More advanced portable self-checkout options allow customers to scan items while shopping, such as by using *smart shopping carts* (Roggeveen and Sethuraman 2020), handheld scanners (Grewal et al. 2020b) or their own mobile devices (e.g., facilitated by their app, see Appendix – Interview 11).

Fully automated checkout technologies go even further, by automatically capturing the products that customers put in their bags or carts, as in Amazon Go or Fresh stores. Prior research suggest that consumers prefer automated over self-checkout (Cui and van Esch 2022; van Esch, Cui, and Jain 2021), but another study also cautions that even if customers perceive higher autonomy, autonomous checkout ultimately does not affect retail patronage (Benoit, Altrichter, and Grewal 2023). The latter is supported by reality since autonomous stores also have been slow to emerge (Faithfull 2021); Amazon initially predicted it would open 3000 Amazon Go stores by 2021 (Convenience Store News 2019), but as of 2023, only 40 are in operation, and only in the United States and United Kingdom (Eley 2021). To explain this constraint, some recent research suggests that the need to check-in (access convenience), lack of means to ask questions of employees (support convenience), and inability to verify purchases prior to leaving the stores (verification convenience) are major points of friction (Benoit, Altrichter, and Grewal 2023). In response, based on lessons learned from Amazon's first attempts and major obstacles, second-generation autonomous stores, such as Carrefour Flash 10/10, do not require customers to check-in, and though cameras still track their movements and capture their baskets, the actual checkout and payment process takes place at terminals, so customer can verify bill correctness before paying (Into the Minds 2022). Also, a staff member is always present, providing greater support convenience.

Quadrant 2: Efficiency Gains for Employees

Technology initiatives in non–customer-facing domains can provide benefits, and yet create less risk for customer relationships. Thus, literature suggests focusing initially on non–customer-facing domains (Guha and Grewal, 2022; Shankar, 2018), such as by increasing employee efficiency. We concur and propose that retailers might benefit most from in-store technology initiatives that help employees perform their existing roles, with regard to managing (1) the store, (2) products, and (3) other employees, with more efficiency. As mentioned before customers will often indirectly benefit from this increased employee efficiency through quicker service. This is in line with one expert emphasizing in our interviews that apps need to combine multiple functions (see Appendix – Interview 11) likely combining customer-facing and non-customer facing functions. Referring to technology more broadly, Guha et al. (2021) describe it as a key driver of retail performance but also note that senior managers seek to balance risk and return, such that they pursue returns in the form of increased revenue but worry about risks related to implementation (e.g., technology, data) and glitches that might undermine customer relationships.

Managing the Store Facility

To manage the store (independent of the type of retail store), employees (whether direct or contract) undertake tasks such as cleaning the store (often after hours) and providing security (especially after hours). With their purposefully minimal customer interface and routinized tasks, these activities appear particularly suitable for technology initiatives. For example, after hours, malls and large retail stores need security patrols, which might be provided by K5 security robots (Davenport et al. 2020; McGinnis 2023; also see Exhibit 2a). Able to operate in various conditions, these robots offer enhanced surveillance capabilities (e.g., video, thermal detection) and are quite effective. Using such robots increases efficiency, such that fewer human security employees are needed, and crime-related outcomes should be better, because the presence of robots should deter crime.

Cleaning also often takes place after hours; the Whiz in-store robot provides such services (Rindfleisch et al. 2022; also see Exhibit 2b and the Appendix - Interview 2). Developed by Softbank, this robot is used by more than 2500 Japanese firms, and one chain uses it in more than 75 stores (Rindfleisch et al. 2022). It also increases effectiveness; on tests of cleanliness, Whiz cleaned better than humans (Rindfleisch et al. 2022). Janitorial companies also acknowledge that, by using Whiz, they can increase their service efficiency and crew productivity by as much as 25% (Softbank website, BES case study 2023)

However, it is important to clarify upfront that these robots do not eliminate the need for human employees, who must program tasks and maintain control over the robots. Both K5 and Whiz can tip over, often by accident, which requires a human employee to troubleshoot. Also, security in some areas (e.g., stairwells, uneven terrain) and cleaning in other areas (e.g., tight spaces, stairs) still require human efforts. Furthermore, an open question remains regarding whether such technologies can be implemented during store hours, when the robots can come face-to-face with customers. The robots are purposefully programmed to move slowly and avoid humans; some stores that have experimented with using Whiz during store hours even display sales promotion signage on it, for customers to see (Rindfleisch et al. 2022). But any negative encounter with a customer, such as if a robot were to physically bump a customer, would likely spark negative publicity (Hrala (2016) documents a case in which the K5 robot ran over a child). In addition, not everyone responds to new technology positively, such as when one suspicious consumer, lurking around a parking lot, prompted a security robot to follow him, and then assaulted the robot when he noticed it (Samson 2019). Uncomfortable consumers might actively and negatively engage with robots, such as knocking them over or causing damage.

Managing Products and Pricing In-Store

To manage product considerations, depending on type of store, employees' roles may include careful product stacking on shelves, checking and modifying product prices, identify misplaced or missing products, and so on. Technology initiatives can play a role, completing some portion of the tasks more efficiently or better, and also increasing employee efficiency. Retailers also use robots to identify spills in retail stores. The Marty robot then alerts retail store employees and cautions customers to stay away from that area, using its multilingual capabilities (e.g. in the US, Marty can communicate in both English and Spanish). Early trials in Giant stores indicated greater in-store efficiency, resulting from Marty's ability to free employees up from such tasks (Abeysinghe 2021). A similar robot version in Australia is named Millie, as used by the retailer Woolworths.

Now consider the case of Walmart, which is at the forefront of using technology in stores. The robot called Auto-C (Exhibit 2d) cleans stores while also capturing images of every item on the shelves—more than 20 million pictures per day. The retailer's in-house inventory algorithm then scans these pictures to identify the various brands and inventory represented therein, with consideration given for lighting quality or shadows. If inventory levels are below some threshold, the system sends an alert for restocking, which encompasses the entire supply chain. If the product is completely out of stock (no replacement inventory available at that store), the system can prompt immediate replenishment, skipping the stock room, the minute the next delivery occurs. Thus, popular items get on the floor far more quickly, and employee productivity and efficiency increase as well (Caminiti 2023).

Tally robots can scan shelves to find incorrect pricing or misplaced or missing products (Guha et al. 2021; also see Exhibit 2c). Tally's manufacturer claims that its use for store audits boosts store and employee efficiency compared with manual audits, in terms of both frequency and accuracy, because each robot can conduct audits multiple times per day, and it achieves nearly perfect accuracy, whereas a manual audit might take multiple days, and the average accuracy of human auditors is estimated at only 65% (Sudborough 2023). Tally is equipped with sensors that help it navigate the store layout and is subject to certain speed and movement constraints when it shares an aisle with customers.

But even if Tally quickly and accurately identifies misplaced or mispriced products, correcting the problem still requires efforts by a human employee. More broadly, robots are limited in several ways. Beyond the complications imposed by the technology's ability to read information on pricing labels and product packaging, as well as navigate store layout, we must also consider the complications associated with the co-presence of customers and robots in the store at the same time.

Beyond the points above, there are concerns relating to the threat of such robots to human employees' job security. Also, some observers note the potential for customer privacy concerns, even when the technologies do not interact directly with customers. For example, these technologies rely on in-depth surveillance and video scanning to monitor people's consumption behaviors, which may create a sense of being watched. Other customers might worry about being falsely accused of inappropriate behavior by a robot, and if so, this would constitute a negative in-store experience for customers (Abeysinghe 2021).

Managing Employees

In their interpersonal encounters with customers, employees may be prone to offer unauthorised discounts or benefits, a practice generally known as "sweethearting"

(Brady et al. 2012; Dijkstra 2021). In some cases, such offers can encourage customer relationships, such as if a cashier allows a regular customer who forgot their wallet to take their cup of coffee for free on a particular morning. But in other cases, the practice is more nefarious, as if employees scan fewer items than the customer, perhaps a friend, brings to the checkout counter but allows them to walk out of the store with all the items. Some estimates indicate that more than half of all retail store employees engage in sweethearting (Brady et al. 2012), which suggests the pressing need to control inappropriate uses. Surveillance technologies such as ScanItAll rely on cameras throughout stores, but especially near checkout areas, to identify signals of employee sweethearting, such as covering up barcodes with their hand or stacking multiple items together (Alkhaldi 2021). At the Piggly Wiggly supermarket chain, monthly shrinkage losses of nearly $10,000 dropped by about 90% after the installation of ScanItAll cameras and algorithms. Arguably, such technologies provide benefits through two paths: a deterrence effect that reduces employees' willingness to engage in risky sweethearting and an efficiency outcome, such that managers can use the technology to identify problems more quickly and intervene appropriately.

Quadrant 3: Enhancement Gains for Customers

Understanding the consumer decision-making process has broadened out and is nowadays more commonly discussed as customer journey management (Grewal, Levy, and Kumar 2009; Lemon and Verhoef 2016; Puccinelli et al. 2009). While customer-enhancing technologies might make shopping trips more efficient, they might also enhance the experience and create a better overall shopping experience for consumers. For example, apps, mixed-reality solutions in the physical store environment, smart displays, AI-generated shopper communication, customization, and smart technologies can empower shoppers to do and experience things that were not previously available in a physical environment. Notably, most of these customer-enhancing technologies are not - and should not be - standalone innovations (see Appendix - Interview 11), but instead build on interconnected technologies, data sources and functions to be able to enhance customer in-store shopping experiences.

The Experience and Store Accessibility

Most major retailers (and many smaller ones) have their own apps, which feature increasing sophistication and support from algorithms (and AI) that reflect data gathered from many different sources, such that they can offer personalized solutions for individual shoppers' needs. Many of these apps involve more sophisticated solutions, as more and more data become available from both the retailers and other sources. As one of our interviewees put it: "in one of the grocery stores we work with, we can utilize information about which car the shopper bought from the company's car dealership. If they buy electric vehicles, we might assume that they care more about environmental causes and can then provide promotions for more environmentally friendly grocery products" (see Appendix - Interview 3). These apps also provide helpful functions such as self-scanning and payment opportunities (e.g., Sainbury's SmartShop, Waitrose's Scan as you go), individual discounts, shopping lists aligned with recipes and store maps (e.g., Kesko), and information about a product's environmental footprint (e.g., H&M). They also encourage cross-channel shopping (Narang and Shankar 2019).

Because apps are linked to customers' digital identities, they allow shoppers to gain access to completely unmanned or autonomous stores (Park and Zhang 2022). Beyond the efficiency gains related to them such as automated basket capturing and checkout (see quadrant 1), autonomous stores also increase customer experience. In Sweden, ICA's app works as a self-scanning device during the day and then as a key to the store at night (Exhibit 3a), increasing the availability of this store to consumers. By linking their app to the Swedish national digital identity system (BankID), shoppers earn the privilege of unlocking the physical store after it has closed and go about their shopping as normal, scanning products using the app and paying using a linked debit or credit card. In addition to the convenience provided for people with last minute or late-night needs, this technology has prompted a new category of unmanned stores in rural areas. One of our industry interviewees highlight the positive reception of such technical solutions for such communities: "These are very popular in more rural areas and often managed by larger stores in the center of that community" (see Appendix - Interview 9). The enhanced customer experiences feature substantial value, by allowing people to shop when and where is most appealing to them. We anticipate that connected apps and smart devices will continue to make retailers more and more accessible.

Digital Experiences in Physical Environments

The software company Ombori promises a novel grid technology, through which shoppers can interact with a retailer's software to determine inventory counts, send messages or questions to the nearest staff member, or gather information about garments they have brought into the dressing room (as is also possible using smart mirrors installed by H&M in some New York stores). Another initiative seeks to overcome the space limitations that are inherently created in physical retailing by providing 3D-rendered product models on interactive screens (e.g., 3ngage; Exhibit 3b). Thus, the store can showcase products that are not in stock to give shoppers a sense of the broader alternatives available to them, such as how the inside of a different refrigerator model looks or how an induction stovetop works (see Appendix - Interview 8). Such displays also can provide technical and operational details that may not be obvious from physical displays or instruction manuals. For example, customers can get a lesson on how to change the string on their garden trimmer without having to turn on the noisy machine, with more detail than can be provided merely by written instructions. Such displays also might allow them to build customized product versions, to envision how they might look.

In-Store Communication

As we noted, for customers, waiting for in-store services is a major "pain point" (Kahn 2018). Various technologies attempt to address it and thereby enhance customers' experience by using in-store communication tactics. *In-store kiosks* and *smart shelves* can provide additional information about products (Grewal et al. 2020), and retailers seem poised to increase the breadth of information and interactivity offered by these technologies. For example, sensory projectors can extend the physical environment by showing how products can be used (e.g., Schweiger et al. 2023) or proposing combinations, as IKEA does in the carpet departments of many of its stores. In fashion retail stores, *smart, virtual, and magic mirrors* can make the shopping experience both more informative and more fun, by listing information about size availability, color options, and product information (Exhibit 3c), then offering inspiration for compatible items and links to social media to allow shoppers to share their looks with friends (Dekimpe et al. 2020; Grewal et al. 2020; Roggeveen and Sethuraman 2020). As such technologies become more affordable (see Appendix - Interview 5 with a regional CTO), we envision such technologies to grow in use. Further, increasing adoption of headsets in retail stores, such as those offered by Vocovo, allow customers to call employees and receive advice from staff either in the store or at a remote location, as well as ask them to come to a particular aisle to provide assistance as needed.

Quadrant 4: Enhancement Gains for Employees

With technologies that enhance or boost their job performance, employees can gain opportunities or abilities they previously lacked, as well as options for doing their job better, such as providing personalized services for customers that would have been impossible without the technology. For example, exoskeletons/exosuits provide support and strength, smart wearables (e.g., smart glasses) augment employees' capabilities and performance, and other IoT devices can assist in customized, personal selling.

Exoskeletons/Exosuits

Exoskeletons are hard, rigid structures worn over the body; exosuits are made of softer materials that frame the body and are lighter, so they require less energy to engage. For our purposes though, we refer to both supplements as exoskeletons, which can be passive or active. Passive versions offer support (e.g., of the arms, legs, back), with devices such as springs and dampers, but they do not augment people's strength or capabilities. In contrast, active versions provide additional strength through hydraulic and mechanical means (O'Connor 2021). Both passive and active exoskeletons can assist employees in lifting tasks and repetitive movements, as well as improve their endurance (Marinov 2015; Mende et al. 2023). Such tools are prevalent in warehouses and manufacturing plants, where they can help prevent employee injuries while also increasing their capacity to lift or move items (Jurczak 2019). Their use by customer-facing employees is less prevalent, with the notable exception of healthcare workers, who often use back and lower limb support to move patients to and from beds, wheelchairs, or bathtubs. Back support exoskeletons can alleviate 10%–40% of back muscle activity in caregivers (de Looze et al. 2016) and thus reduce overuse injuries. We also anticipate more expanded uses for brick-and-mortar retail employees to use exoskeletons, especially as they become more common for everyday activities, such as sporting activities (Volpicelli 2021). If a customer wants a product on the top shelf of a home goods store, employees need to bring a ladder into the aisle to retrieve the item; if they were equipped with exoskeletons with hydraulic lifting power, they could grab the item with a press of the button. These employees also could carry large, bulky, or heavy items to the checkout counter and parking lot for customers. Such enhancements might seem futuristic, but we posit that exoskeletons could be the personal protective equipment of the future.

Smart Wearables

Common examples of smart wearables, defined as "electronic devices that can be worn as accessories, embedded in clothing, implanted in the user's body, or even tattooed on the skin" (Hayes 2022, p. 1), include fitness trackers and Google glasses. But this industry has grown significantly and have become more specialized. Microchips attached to fingertips, enabled with radio-frequency identification (RFID), promise to replace keys and passwords. If a customer that wants to see a product behind a locked case (as used for security in jewelry or electronics departments), an employee might open the case with a tap of a finger (Hayes 2022), rather than having to search for keys. Smart socks, rings, shoes, gloves, and other accessories can monitor dehydration, temperature, heartrates, lifting techniques, and other biometrics (BLE Mobile Apps 2017a; Conure 2022) and thereby help ensure employees are performing optimally or intervene if they are struggling. Smart jackets produced by Levi's embed Google sensors in the left sleeve and thus allow wearers to receive alerts, take calls, ask Google assistant questions, and use the built-in navigation system (Levi.com 2020). Employees wearing such jackets (likely with the retail brand on it) can stay better connected with customers, rather than being distracted or appearing inattentive if they were to use their own phones for such tasks. New versions of smart glasses can provide a host of employee opportunities including allowing them to better access resources and enables them to better serve their customers (BLE Mobile Apps 2017b).

Customized and Personalized Selling

In-store tablets and other AI-powered devices effectively assist employees' customized, personal selling efforts. Rimowa, a luxury luggage company, provides employees with tablets, on which they work with customers to create personalized luggage, using various colors, wheels, handles, and tags, such that employees can offer ideas and suggestions. Employees and customers see the creation immediately, so customers know precisely what they will be getting in their personalized luggage (Gall 2019).

Such tablets and handheld devices also give employees real-time customer information (e.g., last item purchased, preferred colors) to improve their personalized service delivery and address a limitation of in-store retailing, relative to online. That is, while online retailers can instantly recognize customers using sign-in functions and web cookies, *in-store* recognition is difficult and might not occur until customers check out or present a loyalty card. At this point though, retailers have lost valuable opportunities to influence customers' purchasing journeys (Bates 2017; FaceMe 2023). With smart eyewear being developed by SAP Innovation Lab, called "total customer recall" (Bates 2017, p. 1), employees instead can access key customer metrics when the integrated facial recognition software detects that a particular customer has entered the store (see Exhibit 4a). The combination of facial recognition technology with portable tablets or wearables also increases employees' mobility while interacting with customers, rather than forcing them to check a terminal for information (Gran 2018). Other uses of facial recognition technology identify customers' mood states. As one provider acknowledges, "it can be difficult to discern how consumers feel about a retail experience, or about the products they are buying or avoiding. Facial recognition can help with this by assessing and charting emotions: happy, sad, angry, surprised, indifferent, etc." (FaceMe 2023, p. 1). Walmart already has a patent for a technology to identify the facial expressions of customers as they check out; using AI-based algorithms, it can create an index of in-store customer satisfaction and thus identify points for improvement (Soni 2022).

Beyond employees' own efforts, other IoT devices, such as kiosks and digital signage, can detect repeat customers and alert employees to greet the customer by name or offer tailored promotions and recommendations (Bates 2017; see Exhibit 4b). When they go to check out, these recognized customers would not need to present their loyalty cards or remember their loyalty numbers (Noble and Phillips 2004), because the technology would recognize them. They also might skip the step of pulling out their credit cards, because facial recognition can be integrated with point-of-sale systems to authorize payments (Exhibit 4c); 7-Eleven in Japan and Alibaba in China have begun testing such facial recognition payment methods (Soni 2022). If connected across branches of stores, the technology could alert employees to a regular customer who usually visits a different location (FaceMe 2023).

Finally, facial recognition data can be extrapolated to new visitors. Amazon has used a similar type of extrapolation for years, but identifying in-store customer profiles and extrapolating them to other in-store customers is much more difficult. At SAP Innovation Lab, a prototype uses inputs from existing in-store data on facial features, then uses machine learning to extrapolate the information in the form of suggestions for new customers who match the profile (Bates 2017; Soni 2022). If a male consumer, in his 30 s, with a neutral expression on his face, walks into a wine store and buys a bottle of white wine, the next 30ish-year-old man with neutral visage should alert employees to approach that customer and make suggestions about white wine, or else trigger a digital display at the store entrance to showcase popular white wines. As these examples illustrate, facial recognition solutions can transform the retail landscape by giving employees a vast array of information about customers, then using that information to extrapolate recommendations and enhance the retailers' abilities to meet (or exceed) customers' expectations.

Future Research Directions

Based on the above developed and presented quadrants, we outline several research directions below, which are summarized in Table 2. As these research directions highlight, stores remain important channels for retailers and integrating relevant technology into them is key for organizations to thrive in today's retail environments. We hope these ideas and this manuscript stimulate future research on the role of robots and AI in in-store retailing.

Research Directions on Customer Efficiency Gains

The emerging technologies described above give rise to several interesting research questions. Might making nearby offline assortments across providers visible during online search significantly increase traffic in stores? Currently, with some notable exceptions, consumers usually do not know whether the demanded product will be available. Removing such friction might be very helpful.

Also, future research could focus on consumers channel switching criteria. It will be interesting to investigate for which shopper missions and products an online search leads to an online purchase versus an offline (nearby) purchase (SOPIS, search online, purchase in-store). Similarly, what the dynamics between acceptable distances to the nearby stores, type of products and need urgency for consumers. Is half a mile for an urgent purchase of a certain type of battery acceptable leading to a visit of the physical store, whereas ¼ of a mile for a less urgent purchase of a cleaning product is not so that it will be ordered online? Put differently, how does waiting time (for a delivery of a product ordered online) trade off with the effort to go to the store?

Increasing customer efficiency with technology-enabled, more efficient in-store communication and navigation will gradually decrease customer touchpoints with retail staff. The mid- and long-term consequences for consumer behavior - in particular, customer loyalty - are largely unknown. Since retailers usually aren't the developers of these technologies, they might lose their competitive advantages over other retailers that could purchase the same technology. Hence, will retailers be able to transport their unique positioning through technology in the same way than through human touchpoints involving staff interactions? And as a consequence will consumers be able to build deeply rooted customer loyalty when the customer journey mainly consists of touchpoints with technology? In other words, will the consumer efficiency gain through replacing human interaction with in-store technology

Table 2
Future Research Opportunities.

	Customer-focused	Employee-focused
Efficiency	Customer efficiency gains (Quadrant 1) - Impact of offline assortments visible on online search on store traffic and channel switching - Impact of increasing number of technology touchpoints on customer loyalty - Negative consequences of frictionless shopping experience particularly payment processes, e.g., will consumer spent more than they can afford - Understanding the role of technology in the post-purchase stage. Such as using apps to return unsatisfactory options, and post reviews.	Employee efficiency gains (Quadrant 2) - Employee perceptions regarding the implementation process of new technology. - Research on extended capabilities and their outcomes on in-store productivity and value-creation. - The role of intrusive surveillance techniques and linked ethical and privacy issues.
Enhancement	Customer enhancement (Quadrant 3) - Machine learning and AI for more personalized communication and its implications - Optimal levels of technologies in brick-and-mortar retailing - Field research to assess full customer journeys to assess where technologies add value - Extending the assortment in brick-and-mortar digitally	Employee enhancement (Quadrant 4) - Employee perceptions when some, but not all, employees are receiving technological enhancements - Ethical issues regarding surveillance, autonomy, and employee privacy - Algorithmic biases and how they impact implementation and use of new technologies

Note: It must be noted that the stakeholders are depicted as customer-focused or employee-focused, but technologies can also be both customer and employee focused.
In a similar vein, the outcome of the technology is depicted as efficiency-oriented or enhancement-oriented, but the outcome could be both.

come at the expense of making retailers more substitutable, since technology might be easier to copy than a certain service culture expressed through staff? Further research could investigate the impact of technology touchpoints on the relationship with customers.

Removing in-store friction could have a "dark side" which future research could address. This would be analogous to the several negative consequences of removing friction online has had. For instance, Youtube's AutoPlay function (also used by other video and streaming services) removes the viewers' friction of pressing the play button by automatically playing the next video. This has led to overuse and addiction, triggering a bill being proposed in the US for banning AutoPlay functions (Guardian 2019). Will removing in-store friction, for instance purchasing grocery in autonomous stores with video cameras capturing the basket and without the salience of payment, lead to consumers buying more than they can afford? For instance, prior research has shown that consumers have a higher willingness to pay when paying with their mobile compared to cash payment since less transparent payment methods trigger more positive price judgments (Falk et al. 2016).

While we have focused a lot on the role of these in-store technologies (e.g., Amazon Go, and other autonomous stores) enhancing customer efficiency in the pre-purchase stage, further research thus should prioritize investigations of how technologies can help customers in the post-purchase stage, when they begin to use the products and services, access customer service agents using mobile apps, return unsatisfactory options, and share information about their purchase with others (e.g., reviews, word of mouth).

Research Directions on Employee Efficiency

All these technologies raise critical research questions related to how technology may contribute to increasing the efficiency of in-store retail employees, especially if the employees express negative reactions toward the implementation of the new technology. Therefore, research should determine which factors induce discomfort with various types of technology, such as robots, including both employee characteristics and trait factors (e.g., extent to which the technology is perceived as a servant). Ethical questions also are pertinent, particularly for security robots, which could reflect biased programming, with troubling implications for society at large.

Beyond considerations of effective implementation, we need research that addresses the potential for expanded capabilities. For example, could Tally be enhanced to feed the inventory it collects into predictive software and thus give retailers new information about how to avoid stockouts or impose dynamic pricing in response to shifting demand? However, the popular press also suggests that robots that roam the stores (e.g. Tally) when customers are present, might face a backlash if customers perceive that such robots might be surveilling customers? Concerns may relate to privacy, that the robot is trying to surreptitiously monitor their buying preferences. Concerns may also relate to trust, that the robot is monitoring for retail theft. How valid are such concerns, what determines the extent of such concerns, and how might these be addressed? Employees also might resent intrusive surveillance technologies like ScanItAll, evoking negative reactions, such as reduced trust in their employer and enhanced quitting intentions.

Research Directions on Customer Enhancement

The retailing industry has adopted recent technological advances relatively quickly, but they are not necessarily leading these developments (cf. our interview with an ICT company's regional CTO; Appendix - Interview 5). Third-party companies such as consultancies employing data scientists can offer shoppers brand-neutral digital assistance, and such offerings may be the most promising direction, taking the form of static or dynamic digital elements that rely on machine learning or AI. For example, many companies already offer store maps through their apps; currently they are still very much focused on efficiency (see section one or www.pointr.tech), but increasingly these maps are coming figuratively alive to also enhance the shopping experience, which further research could focus on. Similarly, increasingly dynamic messages and visual communication can reflect learned outcomes (e.g., OpenAI's ChatGPT or Dall-E image deep learning image generator) and allow retailers to encourage cross-selling in the store or even with other brands, in ways that offer consumers a complete shopping solution. For example, if a customer asks, "What to wear at a wedding with the dress code 'summer chic'," an AI-enabled app could pull a full set of relevant products. A Nordic fashion retailer is focusing its investments on such technologies, with the aim of enhancing the in-store experience and providing individualized, co-created new product suggestions. Their CTO (see Appendix - Interview 6) also highlights that the key is not necessarily to be the best on every single type of technological solution or AI solution, but that good overall value may arise from being the second best across a wide set of different technologies.

Even if such customer-facing technologies add value, shoppers will exhibit varying levels of receptiveness to them. Thus, we need research that determines which technologies can enhance the experience of shoppers who actively seek out brick-and-mortar retailers or who consider searching an enjoyable and value-adding activity. Alternatively, this consumer preference might represent a boundary condition on the capacity of technology to enhance the experience. In a related sense, many of the latest retailing technologies draw on digital visual merchandising concepts and apply them to the physical environment, through a process of digitalizing the physical environment. But some digital tools might be more or less effective for enhancing in-store experiences; for example, shoppers might regard some tools as mere gimmicks. Field research is needed to assess how such technologies alter shopper journeys and to determine if some optimum balance exists between non-digital and digital visual merchandise techniques. Finally, extending the available assortment represents a meaningful enhancement to physical environments. Traditionally, this goal has been attained with catalogs or signposts that link shoppers to ecommerce platforms. New technologies can showcase products, whether in stock or not, in innovative ways, and we need more research to define where in the shopping journey such options should be offered and what options lead to greater cross-channel conversion.

Research Directions on Employee Enhancement

The innovative technologies noted in this quadrant raise several research questions related to the potential outcomes of enabling employees with new enhancements and capabilities. For example, if not all employees receive exoskeletons, might those who have been excluded feel less capable than their technologically enhanced counterparts? Such a perception could create a self-fulling prophecy, such that performance metrics among non-enabled employees might decline. Conversely, employees who receive the exoskeletons might feel less capable, because their performance depends on the technology, not their own effort. Mende et al. (2023) raise similar questions related to the likely influences of exoskeletons on employees' feelings of self-worth or accomplishment. Augmentation by smart wearables prompts parallel questions, related to when and why technological augmentations might benefit or backfire for employees. If the goal is to maximize the strengths of both the employee and the technology (Noble et al. 2022), finding appropriate pathways to that outcome is critical.

These uses also invoke ethical questions. If smart technologies can be placed under the skin (e.g., RFID tags) or on the skin (e.g., tattoos), they create notable surveillance and autonomy considerations. The smart wearables track employees' personal biometric data, which creates a pressing need to ensure appropriate protection of those data to avoid invasions of employees' privacy. Such concerns also stem from facial recognition software, which consumers might not be able to opt-out of when they enter stores. We previously noted concerns about algorithmic biases, which apply to facial recognition software (Gianfrancesco et al. 2018). But further questions relate to how the gathered data may and should be used, and for the benefit of whom (e.g., customers? employees? retailer? society?) (Mende et al. 2023). Another argument holds that facial recognition software can lessen biases, because everyone is being tracked, such that societal benefits could stem from increased facial recognition software, even if it means the loss of individual privacy.

Conclusion

Based on a comprehensive review of managerial and academic literature and expert interviews we proposed a 2×2 framework covering customers and employees, as well as technology's function (increasing efficiency or experience). We identified technologies increasing efficiency for customers and employees versus enhancing the experience for customers or for employees. For each of these quadrants, we identify future research opportunities. We also embed this typology within customers' and employees' journeys to illustrate how technologies can assist with these journeys. We hope these ideas and this manuscript stimulate future research on the role of in-store technologies.

Exhibit 1
Efficiency Gains for Customers

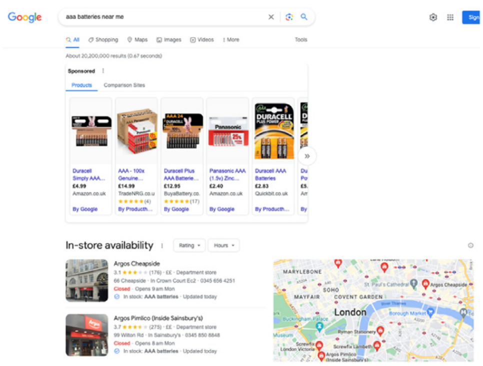

Exhibit 1a: Offline assortments visible on online search.

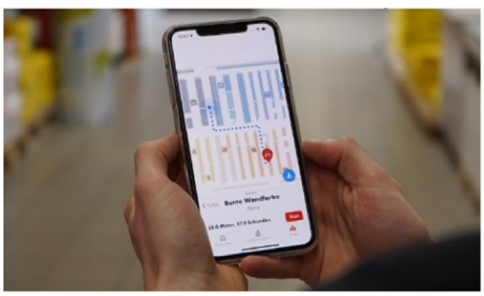

Exhibit 1b: In-store navigation.
Source: https://www.locandis.de/en/instore-navigation-mit-der-app-durch-den-baumarkt/.

Exhibit 1c: Automated basket-capturing.
Source: https://www.geekwire.com/2022/smart-shopping-cart-startup-veeves-new-device-gives-regular-carts-a-high-tech-upgrade/.

Exhibit 1d: Autonomous stores.
Source: https://www.esmmagazine.com/technology/rewe-opens-fully-autonomous-pickgo-store-in-munich-228672.

Exhibit 2
Efficiency Gains for Employees

Exhibit 2a: K5 robot providing retail mall security.
Source: https://wwd.com/business-news/technology/high-tech-robots-act-as-security-guards-in-shopping-areas-in-boston-san-jose-and-sacramento-10897798/.

Exhibit 2b: Whiz robot executing cleaning functions.
Source: https://www.businessinsider.com/softbank-robot-vacuum-whiz-self-driving-tech-photos-2019-11.

Exhibit 2c: Tally robot monitoring store shelves.
Source: https://mobilerobotguide.com/2022/07/15/simbe-partners-with-fast-radius-to-modernize-supply-chains/.

Exhibit 2d: Auto-C robot in Walmart performing cleaning functions and scanning functions.

Source: https://www.cnbc.com/2023/03/27/how-walmart-is-using-ai-to-make-shopping-better.html.

Exhibit 3
Enhancement Gains for Customers

Exhibit 3a: Unmanned stores that can be unlocked by Smartphone apps 24/7.

Exhibit 3b: Interactive 3D rendering of products.

Exhibit 3c: Smart product displays showcasing detailed information about a product when it is touched.

Sources: The Authors

Exhibit 4
Enhancement Gains for Employees

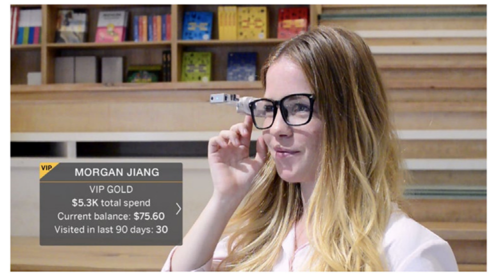

Exhibit 4a: SAP Innovation Lab's 'Total Customer Recall' Solution to Give Employees Access To Key Customer Metrics on Smart Glasses.

Sources: Bates, Drew (2017), "Face Recognition Technology Set To Transform Retail," November 8, Forbes.com: https://www.forbes.com/sites/sap/2017/11/08/face-recognition-technology-set-to-transform-retail/?sh=1465750a4877.

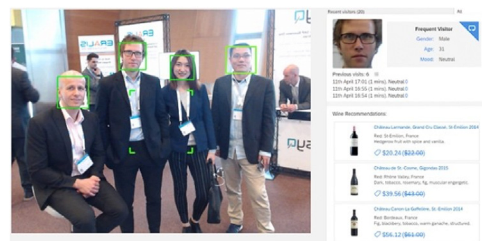

Exhibit 4b: A Prototype of SAP's Facial Recognition Software with Mood Sentiment That Can Extrapolate Existing Customer Data to New Customers to Offer Recommendations.

Source: https://blogs.sap.com/2018/05/18/smb-innovation-lab-face-recognition-with-in-store-analytics/.

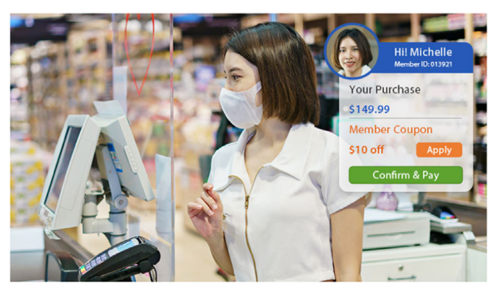

Exhibit 4c. FaceMe Solution for Integrating Facial Recognition and Kiosks for Contactless Payment Options and Personalized Promotions.

Source: https://www.cyberlink.com/faceme/insights/articles/363/smart-retail-with-facial-recognition#:~:text=Firstly%2C%20facial%20recognition%20can%20be,card%20but%20with%20less%20friction.

Appendix

Industry Interviews

ID	Key informant	Relevant domain	Example in-store technologies	Insights
1	Director of Strategic Partnerships, at an AI startup	Customer-Efficiency	LLM, based on a proprietary dataset (food products, specific retail stores)	- Customers use such LLM to find (i) complementary products, (ii) substitute or alternate products, (iii) location of products in-store & (iv) recipes - Phone based app, currently anonymous usage, but next steps would be to link to store reward profile - Currently being piloted in a few mid-Atlantic retail stores - App usage leads to sales lift, with the lift being higher in product categories where customers have less knowledge
2	Researcher, running field studies with Whiz in Japan	Employee-Efficiency	In-store robot, used in over 2500 Japanese firms	- Primary use is cleaning retail locations; used in over 75 Daiei retail stores - Also, Daiei is experimenting using Whiz to display promotions (e.g. wines, cakes). Initial pilot study results are positive - Cleans better than human employee (usual caveats imply, in some locations, human employees better) - Human employees like Whiz; have decorated Whiz in various ways - In instances when Whiz is deployed when customers are in the store, Whiz has avoided bumping into customers
3	Partner at digital transformation company working with major retailers in Northern Europe	Customer-Efficiency	In-app customer shopping lists that are automatically sorted based on the order of the categories in the shoppers' local store	- The focus on all in-store technologies starts with what is value-creating, so we start with how we can make things better for the shopper - We try to connect different types of data sources to customize as many touchpoints for customers as possibly. - We connect data from other retailers that belong to the same corporation. For example, in one of the grocery stores we work with, we can utilize information about which car the shopper bough from the company's car dealership. If they buy electric vehicles, we might assume that they care more about environmental causes and can then provide promotions for more environmentally friendly grocery products. - Often times shoppers don't even realize we're adding these solutions, things just work a little better.
		Customer-Enhancement	Personalized app coupons that can be created when shoppers look at certain recipes. Personalized app coupons based on customers behaviors at *other* retailers	
4	System designer at AV solution firm working with Visual Merchandising in physical retail stores	Customer-Enhancement	Sensors in physical products that activate digital content on screens when they are touched 3D holographic effect systems showcasing and highlighting products	- Digital solutions in-store are getting cheaper and can easily be implemented in store environments. For example, we can put a small sensor in a shoe or on a shelf that activates visual merchandise content on the wall or on a screen in front of the customer when they touch or lift a product. - When a person touches a product, there is a real interest in the product and additional digital content can often be the element that converts the shopper from being interested to actually buying that item. - Holographic effects can be created using relatively cheap LED technologies to highlight specific products with a 3D effect. - Mood buttons for shoppers to push that decides the colors produced by LED lights in the store.
5	Regional CTO	Employee-Efficiency	Smart electric shelf displays that can track location, inventory, and flash when staff or shoppers need to find products. RFID systems that are more accurate	- An issue with a lot of IoT has been that they have been relatively expensive and impractical, running on different systems and frequencies. What was previously made for industry has now become so cheap that it is easy and cost-effective to use connected technologies in retail settings. - New developments, e.g., with WiFi 7 (IEEE 802.11be) makes it easier to use different systems in the same receptors. This makes tracking more accurate and easier. - Smart in-store robots will move more efficiently and not risking connectivity issues as they move through larger retail stores and connect to different access points. - Smart Electric Shelf Labels (ESLs) are very accurate and have many smart functions that can help both retailers and shoppers. For example, pickers in the store can get them to flash to quicker find products they are packing for a specific customer delivery. They can also measure if there are any stockouts and alert staff about such issues. - This technology can allow retailers with tens of thousands of products to have a very accurate map of every SKU in the store. - Shoppers can also utilize the smart tracking of products by searching for products in their app, or on their shopping list, and be directed to the specific product. - IoT can easily be connected to apps to customize prices and in-store promotions for individual shoppers, also in physical stores. - Asian retailers are really leading the way in how to incorporate new and innovative in-store technologies. Europe and the Americas are lagging behind. - A major concern with connected store elements is the privacy issue, especially among Gen Z.

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ID	Key informant	Relevant domain	Example in-store technologies	Insights
		Customer-Efficiency	Smart electric shelf labels can flash when shoppers are trying to find specific products by using their apps	
		Customer-Enhancement	Smart electric shelf-labels can show individualized ads	
6	CTO of Nordic fashion retailer	Employee-Enhancement	Tablets connected to generative AI systems that can support employees when they make suggestions for shoppers	- We want to enhance the customer meeting by letting our staff harness the power of such AI, for example by training them to use tablets which can help them create solutions for customers. We need to make sure they can ask the right questions, though, to get good answers. - You do not have to be the best at all technology, we aren't, but we would love to be second on everything – that is enough for us. - A major part about using innovative technology in the store is also employer branding.
7	Head of public affairs at a not-for-profit organization developing international barcode standards	Employee-Effectiveness Customer-Enhancement	New QR-like standard that may replace traditional bar codes that can contain richer information	- Using a new standard for bar codes, which we were part of developing, we can include deeper information in the product such as expiry dates, and various types of product information. Each individual product can be traced very easily and employees can use it to identify which products are expiring soon or if shoppers require more information about e.g., the source of the product. E.g., Woolworth in Australia, Metro in Germany, and XXL in Sweden have already trialed this technology. - It is also extremely useful for recalls as individual lines of products can be easily tracked as long as retailers connect sales data of unique products to their loyalty programs. - Shoppers can also be encouraged to seek out products close to expiry date with discounts and incentives, enhancing the value for price-sensitive customers while increasing store efficiency.
8	CEO digital product visualization provider	Employee-Enhancement Customer-Enhancement	Interactive 3D visualizations of complex products can be used to showcase special functions of complex products and to be used for after-sales service support	- Many complex products are not connected to the power grid while on display in-store such as white goods. 3D visualizations allow salespersons to showcase unique features of specific products. - They can also be used by shoppers to "play around" with features without fear of doing something wrong or break it. - One of our customers makes diving watches, starting at many thousand euros. They are very complex, and an interactive 3D solution can allow shoppers confidence in how to use the product. You don't want to realize that you don't know what buttons to press when you are 30 m below the surface! - Many products may come in different customizations or versions, but a physical retailer may not be able to keep them all in stock. Alternative options may be showcased on a 3D visualization.
9	Partner, Retail Analytics Firm and CEO for a Retailing Consulting Firm	Employee-Enhancement Customer-Effectiveness	Robotic parcel storage making store pick-ups much quicker IoT checkout solutions	- Many retailers have pick-up services, either for their own products or for other retailers. New technologies that have previously been used in warehouses have now been adapted to in-store format, where automated parcel storage solutions make handing out products to shoppers much faster and more convenient for both the shopper and the employee. - Smart solutions are now in use at Uniqlo fashion stores and Circle K convenience stores in which shoppers just put the products on a reading area, which either scans RFID tags or uses cameras so that no scanning is needed by shoppers or employees, making the check-out solution more advanced.
		Customer-Enhancements	Unmanned grocery stores unlocked by retailer apps	- … have now started two types of unmanned stores. The first type is the container store concept where the store is completely unmanned, and shoppers can unlock the store using their retailer app and digital identity system BankID. This is very popular in more rural areas and often managed by larger stores in the center of that community. - The other solution is the "open after closing hours" solution where shoppers can unlock the regular shop after closing using the same system. These two solutions are growing exponentially, especially in more rural areas.
10	Head of Store Development & Design at a Nordic Retailer	Customer Efficiency	Combination of channels, pickup and autonomous stores	- A Swedish retailer has started offering a combination of pickup lockers in which online pre-ordered groceries are made available with autonomous stores, in which approximately 85% of the assortment customers regularly buy is made available.
11	CEO of a multifunctional app	Customer Efficiency	Combining different functions for customers in one app	- The multi-functional retailer app provides scan-pay-go functionality, in-store navigation, it helps customers find allergens on products, communicates offers and various other functions. - The important aspect is to get the balance right between not creating too many functions so that it gets confusing for customers, but at the same time provide enough functions to make the app valuable for different target groups and shopper missions. - The app is also customizable with the retailer logo and look and feel or used with the apps brands

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