Smart technologies for retailing: who, what, where and why

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Abstract

Purpose – The retail landscape is dramatically changing due to a series of socio-economic and technological challenges, which can be faced through the adoption of smart technologies. Accordingly, a significant number of publications in this field have been produced, albeit with fragmented results. Therefore, this paper aims at both providing a clear and organised overview of the main smart technologies for physical retailing, in terms of application fields and expected impact, while identifying the major shortcomings and future research avenues.

Design/methodology/approach – The research conducts a systematic review of the literature concerning the assimilation of smart technologies within physical retail environments, resulting in the analysis of 103 papers published from 2005 to 2023. The review highlights (1) the main smart technologies employed in retail stores, (2) their application area and (3) the beneficiaries of their adoption. Accordingly, these three aspects are initially assessed independently and then examined in combination.

Findings – The analysis presents a comprehensive list of 16 key technologies (what) that can support a wide range of processes, spanning from back-end functions to front-end activities, also enabling the connection with online channels (where), catering several and different benefits (why) to both customers and retailers (who). Besides, the research points out many uncovered topics that could be addressed by the academic community.

Originality/value – To the best of the authors' knowledge, the review is the first one in the literature offering a thorough and organised overview of the different available technologies for in-store application and their impact on physical retail processes.

Keywords Smart technologies, Technology assimilation, Retailing, Retail processes, Retail store

Paper type Literature review

1. Introduction

In recent years, a series of socio-economic and technological changes affected industries at large, including the retail one (Gupta and Mukherjee, 2022; Klaus and Kuppelwieser, 2022). Such changes may be attributed to three main areas (Babin *et al.*, 2021).

First, consumer preferences are evolving as they are becoming more demanding, posing an increasing challenge for retailers to meet and exceed expectations in terms of both product/service quality and the purchasing experience (Bustamante and Rubio, 2017). Additionally, as lifestyles increasingly embrace digital technologies and the adoption of smart technologies grows, customers are also becoming more technologically skilled (Foroudi *et al.*, 2018; Adapa *et al.*, 2020).

Second, this intense technological evolution is also permeating the industrial world, where it creates a staggering promise and opportunity. Digital advancement translates into a range of disruptions, as well as occasions to improve performances, across every sector (Matzler *et al.*, 2018).

Third, the rise of e-commerce has sharpened competition for traditional retailers, compelling them to redefine the role of physical stores. To stay competitive, offline stores must integrate with their digital counterparts to provide an omnichannel experience (Cai and

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Lo, 2020). In turn, online players venture into physical spaces (e.g. Amazon Fresh, Google store) to enhance the customer experience (Bell *et al.*, 2020).

Overall, the retail landscape is dramatically shifting, and the assimilation of digital technologies plays a crucial role in addressing evolving challenges (Zhu *et al.*, 2006; Homburg *et al.*, 2017). Indeed, they facilitate the collection of extensive customer data, comprehend their changing needs and ultimately meet their expectations, in a technology-driven and omnichannel business environment.

Considering these premises, there is a substantial and growing academic interest towards technology assimilation within retail sector (Grewal *et al.*, 2017, 2021), as outlined by the high number of publications in the field (Mostaghel *et al.*, 2022). However, existing literature appears fragmented due to the extensive research scope (Mishra *et al.*, 2021). Some authors examined systematically technologies applications and value creations in retail store processes, but typically focusing on a specific one, such as Artificial Intelligence (AI) (Cao, 2021), beacons (van de Sanden *et al.*, 2019), in-store mobile devices (Cavalinhos *et al.*, 2021), virtual (Xi and Hamari, 2021) and augmented reality (Rejeb *et al.*, 2023). Systemic literature reviews have been conducted also on specific kind of stores enabled by technologies (e.g. cashierless (Szabó-Szentgróti *et al.*, 2023)), or focusing on their effect on in-store customer experience (Lahmeyer and Roemer, 2024). However, to the best of the authors' knowledge, there is a lack of a comprehensive overview detailing the impact of smart technologies on retail store processes. Previous attempts, like Willems *et al.* (2017), moved some steps in this direction, categorised retail technologies based on customer shopping stages but lacked retailer perspectives and specific technological details.

Therefore, this paper aims to fill this gap, by providing a clear and organised overview of key smart technologies for physical retailing, in terms of application fields and expected impact, by answering the following research questions:

RQ1. What are the main smart technologies that could be used in retail stores?

RQ2. Where do smart technologies have an impact on store processes?

RQ3. Who are the main beneficiaries of smart technology assimilation?

RQ4. Why should smart technologies be adopted in retail stores?

So, the present research aims to enrich the academic conversation about technology assimilation for physical retailing, by providing a comprehensive classification of the relevant literature within this field and proposing paths for future research activities in line with the identified gaps. Additionally, it serves as a valuable tool for retailers embarking on a technology assimilation journey, particularly in the initiation phase (Zhu *et al.*, 2006). By identifying technologies that could meet their needs and evaluating potential benefits, this research provides crucial guidance for making informed decisions.

The remainder of the paper is organised as follows. Section 2 illustrates the methodology adopted, while Section 3 highlights the results of the analysis. Section 4 discusses the findings and the gaps arising. Finally, Section 5 summarises the contributions and the implications.

2. Methodology

Given the extensive research already developed on the topic, a systematic literature review was performed to answer the research questions, following a three-step methodology, adapted from Mayring (2000).

(1) *Material collection:* definition and delimitation of the material to be collected.

(2) *Category selection:* definition of the dimensions according to which the content-based review is performed.

(3) *Material evaluation:* classification and analysis of the collected material according to the selected categories.

2.1 Phase 1: material collection

The material collection process was composed by four main stages, adapted from Srivastava (2007).

- *Classification context definition:* the implications of adopting digital technologies on in-store retail processes.

- *Definition of the unit of the analysis:* single scientific paper published in a Q1 international peer-reviewed journal (Scimago ranking), similarly to previous literature reviews in the retailing field (e.g. Tyrväinen and Karjaluoto, 2019).

- *Collecting publications:* three main research using different keywords were performed to retrieve relevant publications from Scopus and Web of Science (WoS) library databases. More in detail, keywords are related to combination of different technologies in retail area, to the new retail concept (e.g. smart retailing) and to the omnichannel digitalisation of the store, as clarified in Table 1. The terms were searched for in title, keywords and abstract of the papers belonging to "Business, Management and Accounting" area for what concerns Scopus database, and "Business" and "Management" for WoS, all written in English. Paper extraction was performed on September 4th, 2023. As observable from Table 1, the keyword "metaverse" was not incorporated into the search criteria. Despite the growing interest of the academic community in this technology due

Keywords	References
Keywords	
("Smart shel*" OR "Smart mirror*" OR "interactive mirror*" OR "Smart display" OR "interactive display" OR "augmented reality" OR "virtual reality" OR "beacon*" OR "smart camera*" OR "smart cart*" OR "smart shopping cart*" OR "smart basket*" OR "smart shopping basket*" OR "smart fitting room*" OR "interactive fitting room*" OR "sensor*" OR "shopping assistant system" OR "near field communication" OR "NFC" OR "self-service technolog*" OR "SST" OR "self-checkout" OR "informative touchpoint*" OR "Internet of things" OR "iot" OR "artificial intelligence" OR "AI" OR "RFId") AND (TITLE (retail) OR KEY (retail))	Renko and Druzijanic (2014), Roy *et al.* (2017), Wolpert and Roth (2020), Baier and Rese (2020)
"smart retail*" OR "smart shop" OR "smart store" OR "retail 4.0"	Pantano and Timmermans (2014)
retail* AND (omnichannel OR omni-channel) AND (digital OR technolog* OR smart)	Jocevski (2020)

Inclusion criteria	Exclusion criteria
Criteria	
Technology adoption for in-store retailing	Technology adoption for online retailing
Technology adoption for in-store retailing activities	Technology adoption for retail supply chain activities
Technology adoption for B2C market	Technology adoption for B2B market

Source(s): Authors' own work

Table 1. Keywords and inclusion/exclusion criteria

to its substantial influence on the retail industry (Yoo *et al.*, 2023), it falls outside the scope of this analysis. Its application primarily instigates significant changes in online commerce rather than physical retail establishments.

- *Delimiting the field:* the selected inclusion and exclusion criteria are displayed in Table 1.

2.2 Phase 2: category selection

The category application followed a deductive approach, as the research questions guided the development of a category according to which the collected material was classified.

2.3 Phase 3: material evaluation

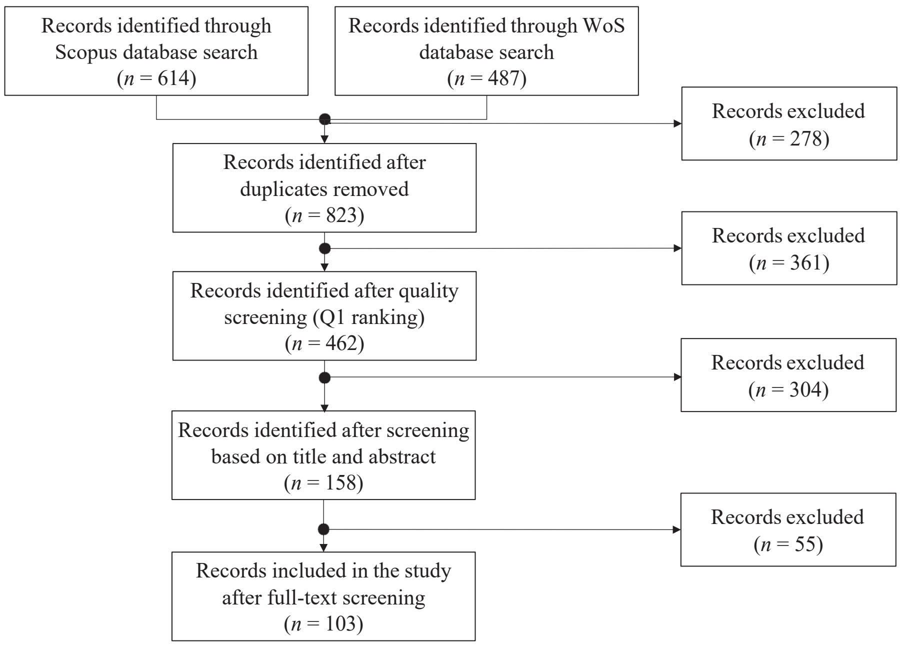
The contributions were summarised and discussed based on the selected categories, to map extant knowledge, and accordingly identify patterns suggesting relevant themes and possible gaps for further research (Bruni and Piccarozzi, 2022).

3. Results

The presentation of the results is structured according to the scheme presented in the methodology section, i.e. material collection, category selection and material evaluation.

3.1 Phase 1: material collection

The initial database resulting from the search phase included 823 papers. A first refinement based on the quality (Q1 journals) reduced the number of records to 462 papers. After the title and abstract screening, a sub-set of 158 papers was selected. The final corpus, obtained after the full-text screening, consist of 103 papers published from 2005 to 2023 (Figure 1).



Source(s): Authors' own work

Figure 1.
PRISMA chart

3.2 Phase 2: category selection

The classification categories were defined to address the research questions, as follows:

RQ1 *Technology*, i.e. the specific technology under study.

RQ2 *Application area*, i.e. the area to which the addressed process pertains.

RQ3 *Perspective*, i.e. the beneficiaries of technology adoption.

The fourth category, addressing RQ4, emerged from the intersection of the three abovementioned categories.

3.3 Phase 3: material evaluation

The collected material was then evaluated according to the three selected category, i.e. technology, application area, perspective and in combination.

3.3.1 Technology. The technology-based classification answers the question *what* (RQ1), by listing most relevant technologies suitable for in-store adoption. The result is summarised in Table 2, which provides also a definition for each technology, the year they first appeared in the selected literature, the number of contributions addressing them, and the main references.

Some papers address multiple technologies, and as a result, the number of papers in Table 2 is higher than the total number of reviewed papers.

Technology	Definition	Year	#Papers	Main references
RFId (Radio frequency identification)	Technology that uses radio waves to passively identify a tagged object and enables real-time item tracking. It allows to associate a univocal code to every handled unit, and to detect it from a greater distance	2005	26	Rekik *et al.* (2008), Thiesse *et al.* (2009), Hardgrave *et al.* (2013), De Marco *et al.* (2012), Condea *et al.* (2012), Zhou and Piramuthu (2013), Landmark and Sjøbakk (2017)
Augmented reality	Interactive experience of a real-world environment where the objects that reside in the real world are enhanced by computer-generated perceptual information	2017	18	Poushneh and Vasquez-Parraga (2017), Dacko (2017), Rejeb *et al.* (2023)
Self-service technologies	Technological interface that allows to provide customers with services, without the involvement of the employee (e.g. self-checkout)	2007	15	Weijters *et al.* (2007), Kaushik and Rahman (2015), Lee (2015), Demoulin and Djelassi (2016), Fernandes and Pedroso (2017)
Artificial intelligence	Systems that can perceive the surrounding environment and take actions that maximise the chance of achieving a goal. In the retail context, it allows retailers to connect with their customers and to operate more efficiently	2019	11	Chopra (2019), Pillai *et al.* (2020), Cao (2021), Guha *et al.* (2021)

(*continued*)

Table 2. Smart technologies definition and diffusion in literature

Technology	Definition	Year	#Papers	Main references
Mobile device	Portable devices that can be carried by the user moving across the store that enable a series of activities allowing customers to get more informed decisions while shopping (e.g. searching for online reviews, getting personalised suggestions, making payments)	2016	10	Taylor (2016), Hoehle *et al.* (2018), Fiestas and Tuzovic (2021)
Interactive display	Display that exhibits digital images, videos, or texts, and allows customer interaction	2017	9	Roy *et al.* (2017), Willems *et al.* (2017), van Giesen and Leenheer (2019), van de Sanden *et al.* (2022)
Internet of things device	Devices and sensors able to gather a great amount of data, which can be then exploited for different purposes	2017	7	Balaji and Roy (2017), Caro and Sadr (2019), Fagerstrøm *et al.* (2020)
Robot	Machine that autonomously perform routine tasks (e.g. inventory tracking, locating of items) traditionally in charge of employees	2019	5	Morenza-Cinos *et al.* (2019), Moore *et al.* (2022), Song and Kim (2022)
Smart mirror	Two-way mirror with an inbuilt display behind the glass that can superpose things (clothing or make-up) on customers' image	2018	5	Ogunjimi *et al.* (2021), Schultz and Gorlas (2023)
Virtual reality	Decentralised computing landscape based on a digital world, which displays 3D virtual products and store components	2019	4	Xi and Hamari (2021), Ben Mimoun *et al.* (2022)
Near field communication	Device that communicates with a shopper's smartphone using short-range radio waves. The communication, which allows to exchange information between each other at a short distance, must be initiated by customer	2017	4	Roy *et al.* (2017, 2018)
Beacon	Device that communicates with a shopper's smartphone to push contents using Bluetooth technology (e.g. ads, coupons, supplementary product information)	2019	3	van de Sanden *et al.*, 2019, Lin (2022)
Sensor	Device that detects and responds to specific kinds of input from the physical environment (e.g. count the number of shoppers in a store)	2017	3	Epstein *et al.* (2021)
Smart shelf	Shelf furnished with electronic labels and sensors interacting with the consumers to guide them in the selection and provide information on stock in real time	2017	2	Inman and Nikolova (2017), Boden *et al.* (2020)

Table 2.

(*continued*)

Technology	Definition	Year	#Papers	Main references
Smart fitting rooms	Fitting rooms equipped with interactive touch-screen mirror connected to an RFId reader and a motion sensor. They sense when customers enter it and what items they have brought in by reading their tags	2012	2	Wong *et al.* (2012)
Smart shopping cart	Shopping cart whose position is tracked through appropriated geo-localisation technologies. Moreover, they can automatically recognise items as they are placed in the cart, enable self-payments and display advertisement	2017	2	Roy *et al.* (2017), Inman and Nikolova (2017)

Source(s): Authors' own work

Table 2.

3.3.2 Application area. The categorisation concerning application areas addresses the *where* aspect (RQ2) by delineating the specific processes where technologies are applied. More in detail, these processes are structured around two primary areas, adapted from Taylor *et al.* (2019).

(1) Front-end: activities that involve an interaction with the customer (pre-sales, product choice, check-out, and post-sales). These activities can enable behaviours that exploit multiple channels (eCommerce, mobile commerce, mobile App, social media), in an omnichannel logic.

(2) Back-end: inventory management and other transversal processes such as customer-relationship-management (CRM).

Front-end (and omnichannel). The front-end area has garnered significant academic attention, with 89 papers focused on it, 32 of which adopt an omnichannel perspective. This area encompasses various activities that can be distinguished into three main phases: pre-sales, product choice and check-out.

(1) The pre-sales phase involves guiding customer purchases through targeted marketing, advertising, and data-driven promotions that align with customer preferences, facilitated by digital technologies (van de Sanden *et al.*, 2020; Wong *et al.*, 2012). During this phase, customers also actively seek additional product information and reviews across online channels before making decisions (Fiestas and Tuzovic, 2021; Zhang *et al.*, 2022).

(2) The product choice refers to the phase in which customers select the products that best suit their needs and make the purchase decision. Different technological solutions could enhance this phase, by streamlining the selection process and facilitating more informed decisions, such as by recommending related products (Ogunjimi *et al.*, 2021; Wong *et al.*, 2012).

(3) The last front-end phase involves payment and check-out activities that are expedited by technologies, which, in some cases, enable online check-out (Hoehle *et al.*, 2018; Liang *et al.*, 2022; Taylor, 2016).

Back-end. The studies investigating the back-end area (26 papers) aim at optimising operations and logistics activities. These processes firstly improve the planning decisions of retailers, but ultimately positively impact customers as well, e.g. by reducing the occurrence of stock-outs (Hardgrave *et al.*, 2013). The most addressed activity is inventory management, where technology enables tracking items and provides real-time information about their availability and location (Hardgrave *et al.*, 2011; Morenza-Cinos *et al.*, 2019). Another analysed activity is shelf replenishment, as the adoption of innovative technologies may lower the occurrence of misplacement errors and prevent theft (Rekik *et al.*, 2008). However, technologies can also enhance other processes, such as demand management and customer-relationship management (Cao, 2021). Moreover, benefits may be reached by reducing the time spent by employees in backroom operations, who can instead assist customers (De Marco *et al.*, 2012).

3.3.3 Perspective. The perspective analysis offers insight of *who* are the main beneficiaries of technology adoption (RQ3), namely customers and retailer, who represent the two major actors around which the store experience is built and works.

Great attention is paid to *customers* and their attitude towards technology adoption in the stores (counting 65 papers). Indeed, understanding customer attitudes toward retail technologies is crucial as it offers retailers valuable insights into preferences that directly influence sales and profits.

All benefits to customers, manifesting as increased satisfaction, arise from various situations but primarily fall into two categories aligned with customer shopping orientation theories: utilitarian and hedonic (Babin *et al.*, 1994; Chang and Chen, 2021).

The utilitarianism-based shopping orientation refers to goal-oriented consumers, who typically make their purchases based on considerations about cognitive-oriented benefits, rational necessity, and needs (Babin *et al.*, 1994). The application of in-store digital technologies aids these customers in pursuing their goals more efficiently, by providing enriched information about products, facilitating informed choices aligned with various aspects (e.g. price, quality, or sustainability) (Boden *et al.*, 2020; Fiestas and Tuzovic, 2021; Roy *et al.*, 2018). Smart technologies also allow customers to save time during the different phases of the purchase journey. First, by providing targeted promotions (van de Sanden *et al.*, 2020; Xue *et al.*, 2023). Second, by reducing the time spent trying products (Wong *et al.*, 2012; Ogunjimi *et al.*, 2021). Third, by allowing for a faster check-out process (Fernandes and Pedroso, 2017; Hoehle *et al.*, 2018; Liang *et al.*, 2022).

The hedonic shopping orientation refers instead to those consumers that value the thrills and fun of the shopping experience, and purchase to achieve sensory gratification and excitement (Babin *et al.*, 1994). In this perspective, digital technologies enhance the shopping experience with immersive, interactive, and playful value (Alexander and Kent, 2020; Chang and Chen, 2021; Ben Mimoun *et al.*, 2022).

Considering *retailers,* a consistent number of papers may be found (48 articles). These works propose solutions to improve the quality of the processes in charge of the retailers themselves. The application of smart technologies can improve the efficiency (fastening the activities) and effectiveness (allowing for greater accuracy) of the operations. The most cited benefit is related to inventory management (Rekik *et al.*, 2008; Zhou and Piramuthu, 2013). However, such technologies can also enhance other areas, from marketing (Epstein *et al.*, 2021; van de Sanden *et al.*, 2019), to the tracking of customers' behaviour (Cao, 2021; Landmark and Sjøbakk, 2017) to employee efficiency/efficacy (Caro and Sadr, 2019; De Marco *et al.*, 2012).

3.3.4 Technology-application area matrix. Table 3 presents the combined view that emerges by crossing the three categories (i.e. technology, application area, perspective) above presented, with the objective of providing the reasons *why* each technology should be adopted (RQ4), highlighting the main benefits brought.

More in detail, each cell displays the main benefits entailed by each technology (on the rows) in each area (on the columns) and by which actor they are primarily perceived (shown

Table 3.
Benefits enabled by smart technologies in their destination application area

TECHNOLOGY	APPLICATION AREA: Back-end				Front-end				
	Inventory management	Price management	Demand management	Customer relationship management	In-store marketing activities	Information delivery	In-store customer experience	Product choice	Check-out
RFId	Improved accuracy (Rekik *et al.*, 2008; Rekik *et al.*, 2009; Hardgrave *et al.*, 2013); Reduced ticket switching occurence occurrence (Tu and Piramuthu, 2022); Higher stock visibility (Kasiri *et al.*, 2012; Morenza-Cinos *et al.*, 2019); Improved replenishment activities (Condea *et al.*, 2012; Thiesse and Buckel, 2015); Contrast to counterfeiting and theft (Bhattacharya *et al.*, 2010; Zhou and Piramuthu, 2013)	Improved pricing policies (Zhou *et al.*, 2009)	Better customer knowledge (Landmark and Sjøbakk, 2017)		Increase in sale due to cross and up selling activities (Wong *et al.*, 2012)				Speed-up of the activity (Kasiri *et al.*, 2012) Save employee labour (Kasiri *et al.*, 2012)
Self-Service Technologies									Speed-up of the activity (Lee, 2015; Demoulin and Djelassi, 2016; Fernandes and Pedroso, 2017; Duarte *et al.*, 2022)
Augmented Reality					Increase in advertising effectiveness (Rejeb *et al.*, 2023; Zimmermann *et al.*, 2023)	Higher quality of information (Hilken *et al.*, 2018; Sung *et al.*, 2021)	Increase in customer enjoyment of the experience (Hilken *et al.*, 2018; Farah *et al.*, 2019; Hollebeek *et al.*, 2020) Foster store loyalty (Hilken *et al.*, 2018)	Reduced rate of returns (Perannagari and Chakrabarti, 2019)	
Virtual Reality									
Mobile device					Improved and personalised promotions (Schrage *et al.*, 2022)	Higher quality of information gathered online (Schrage *et al.*, 2022; Inman and Nikolova, 2017; Fiestas and Tuzovic, 2021)			Seamless payment experience (Taylor, 2016; Liang *et al.*, 2022)
Artificial Intelligence	Inventory optimisation (Cao, 2021)	Improved pricing policies (Cao, 2021)	Better customer knowledge (Cao, 2021)		Improved and personalised promotions (Pillai *et al.*, 2020; Cao, 2021)		Increase in customer enjoyment of the experience (Pillai *et al.*, 2020; Cao, 2021; Sung *et al.*, 2021)		Seamless payment experience (Pillai *et al.*, 2020; Cao, 2021)
Internet of Things	Inventory optimisation (Caro and Sadr, 2019)				Improved and personalised promotions (Balaji	Higher quality of information (Balaji and Roy, 2017;			

(continued)

Table 3.

					and Roy, 2017; Fagerstrøm *et al.*, 2020) Improved and personalised promotions (Caro and Sadr, 2019)	Fagerstrøm *et al.*, 2020)			
Interactive display					Increase in advertising effectiveness (Willems *et al.*, 2017; van Giesen and Leenheer, 2019)	Higher quality of information (Willems *et al.*, 2017; van Giesen and Leenheer, 2019)	Increase in customer enjoyment of the experience (Willems *et al.*, 2017; van Giesen and Leenheer, 2019)		Seamless payment experience (van de Sanden et al., 2022).
Robot	Higher stock visibility (Morenza-Cinos *et al.*, 2019).					Help in finding product and personalised product advice (Song and Kim, 2022)			Seamless payment experience (Song and Kim, 2022)
Beacon					Increase in advertising effectiveness (Inman and Nikolova, 2017; van de Sanden *et al.*, 2019; Lin, 2022)	Higher quality of information (van de Sanden *et al.*, 2019)	Increase in customer enjoyment of the experience (van de Sanden *et al.*, 2019)		
NFC									
Smart shelf	Improved replenishment activties and improved accuracy (Inman and Nikolova, 2017)	Improved pricing policies (Inman and Nikolova, 2017)			Increase in advertising effectiveness (Inman and Nikolova, 2017)	Higher quality of information gathered online (Boden *et al.*, 2020)			
Smart mirror								Speed-up of the activity (Ogunjimi *et al.*, 2021) Reduction of information cost (Schultz and Gorlas, 2023)	
Smart fitting rooms					Increase in sale due to cross and up selling activities (Wong *et al.*, 2012)			Speed-up of the activity (Wong *et al.*, 2012)	
Smart shopping cart					Improved and personalised promotions (Roy *et al.*, 2017)	Higher quality of information (Roy *et al.*, 2017)	Increase in customer enjoyment of the experience (Roy *et al.*, 2017)		
Sensor				Conversion rate measurement (Epstein *et al.*, 2021)		Higher quality of information (Hoehle *et al.*, 2018)			
Benefits for	Retailer	Customers	Retailer and customers						

Source(s): Table by authors

by the different colours used for the text). The cells with grey background, instead, indicate that the presented benefits are achievable through the exploitation of multiple channels (i.e. the physical plus the online one), in an omnichannel logic.

RFId is mainly used for inventory management, benefitting retailers by minimising misplacements and inaccuracies (Rekik *et al.*, 2008, 2009) and preventing ticket switching (Tu and Piramuthu, 2022). It enhances stock visibility (Kasiri *et al.*, 2012; Morenza-Cinos *et al.*, 2019) and shelf replenishment activities (Condea *et al.*, 2012; Thiesse and Buckel, 2015). RFId also aids in contrasting counterfeiting and theft (Bhattacharya *et al.*, 2010; Zhou and Piramuthu, 2013) and supports dynamic pricing policies, promoting tagged products to specific customers (Zhou *et al.*, 2009). Furthermore, it enhances demand management by tracking customer behaviour and improving customer knowledge (Landmark and Sjøbakk, 2017). On the front end, RFId facilitates cross-selling activities, allowing retailers to identify tagged items picked by customers and promote related products (Wong *et al.*, 2012). It also enables automatic check-out, by charging customers' accounts automatically when they pass through the check-out stations, reducing the time spent at the tills. Additionally, it saves employees' labour that can be spent providing customer service (Kasiri *et al.*, 2012).

Self-Service Technologies (SSTs) are inherently designed for front-end activities, offering a significant advantage in task efficiency, providing an improved experience for both customers and retailers. For customers, SSTs reduce waiting time at the cashier's desk (Duarte *et al.*, 2022; Fernandes and Pedroso, 2017). For retailers, SSTs enable employees to complete tasks more efficiently, freeing up time to serve more customers or tackle additional responsibilities (Weijters *et al.*, 2007).

The Augmented Reality/Virtual Reality family of technologies impacts front-end processes, enhancing both utilitarian and hedonic aspects of customers' experiences. Concerning the former, AR/VR provide enriched product information, enabling the visualisation of the product in the destination context (e.g. by visualising a sofa in a virtual living room) and offering better price comparisons, facilitating product browsing and assortment navigation (Dacko, 2017; Hilken *et al.*, 2018; Chiu *et al.*, 2021). Concerning the latter, AR/VR create memorable in-store experience (e.g. proposing gamification through which customers gain some promotions or perform the purchase), increasing fun and time spent in-store (Farah *et al.*, 2019; Hollebeek *et al.*, 2020; Sung *et al.*, 2021). From a retailer's perspective, the cost-effective utilisation of AR and VR for product trials enhances consumer confidence in purchase decisions, reducing return rates (Perannagari and Chakrabarti, 2019). Moreover, these technologies have the potential to boost advertising effectiveness by capturing consumer curiosity and increasing attentiveness to advertisements (Rejeb *et al.*, 2023; Zimmermann *et al.*, 2023). In an omnichannel context, augmentation of the in-store experience holds the potential to foster store loyalty and mitigate the loss of customers to online retailers, declining in-store foot traffic, and showrooming behaviours (Hilken *et al.*, 2018).

Mobile technology enhances customer satisfaction by enabling various omnichannel activities, such as receiving personalised promotions, making payments (Liang *et al.*, 2022), obtaining additional product information, accessing location-based services, loyalty programs (Schrage *et al.*, 2022) or checking online reviews, searching for discounts, and interacting with other users on social media for advice (Fiestas and Tuzovic, 2021).

AI plays a crucial role in both front-end and back-end processes. In the former area, AI is employed for personalisation/recommendation systems (as it allows the collection and leverage of vast amounts of data about purchasing behaviour), in-store customer experience management (by anticipating customers' requests) or payment management (enabling seamless check-out and direct charging of customers for their purchases without an actual checkout activity, as seen with Amazon Fresh). This boosts the overall shopping enjoyment

(Cao, 2021; Pillai *et al.*, 2020). When considering back-end processes, AI improves inventory optimisation (e.g. through a platform that keeps record of the stock and automatically sends a replenishment order), price optimisation (potentially triggering a targeted price promotion for each customer) and customer relationship management (providing a detailed overview of customer preferences that can be leveraged by retailers). Furthermore, AI also enables the anticipation of customer demand, benefiting retailers' planning decisions (Cao, 2021).

Given the versatility of IoT technologies, they find applications across all three areas. Considering the front-end, they enhance the shopping experience by providing real-time personalised information and promotions (Balaji and Roy, 2017; Fagerstrøm *et al.*, 2020). In the back-end area, IoT improves inventory management and related logistics activities (e.g. with in-time stock-out alerts activated by sensors) (Caro and Sadr, 2019). Considering the omnichannel experience, IoT enables targeted actions towards customers, such as marketing ones, by leveraging customers' mobile devices and GPS-based location tracking in-store (Caro and Sadr, 2019).

The interactive display, by its nature, is designed to engage customers and is primarily used for front-end activities, showcasing advertising and information (e.g. about the origin and sustainability of products) (van Giesen and Leenheer, 2019). Consumers can access enriched data, browse store catalogue and seek additional information for more informed choices (Willems *et al.*, 2017). In some instances, the display also facilitates order placement and payment (van de Sanden *et al.*, 2022).

Robots can be employed both for back-end and front-end tasks. Concerning the former, when combined with RFId tags and readers, they automate and provide accurate, cost-effective, and nearly real-time visibility of items and their locations in the store (Morenza-Cinos *et al.*, 2019). In the latter case, robots assist customers by helping them locate products, offering personalised advice, and facilitating purchase transactions (Song and Kim, 2022).

Beacons and NFC facilitate proximity marketing activities (Inman and Nikolova, 2017; van de Sanden *et al.*, 2019), triggering customers' reaction and delivering enriched product information when customers are near targeted items, ensuring immediate engagement.

On the other side, they deliver values to customers in three ways (van de Sanden *et al.*, 2019).

(1) By improving convenience in-store and achieving money savings (cost/effort reduction).

(2) By providing product information and facilitating comparison of alternatives (utilitarian benefit).

(3) By enhancing the experience in hedonic terms.

The smart shelf is a versatile technology, applicable in all three application areas. It allows retailers to be more in control of activities such as inventory tracking (as it provides the exact quantity of products exhibited on the shelf), real-time price management (enabling dynamic pricing activities, thanks to the digital label) and advertising actions (by sending messages to customers' phone in order to promote specific items on the shelf, e.g. those close to the expiring date) (Inman and Nikolova, 2017). In omnichannel activities, it displays integrated price information, preventing customers from switching channels and blending online strengths with brick-and-mortar stores, saving customers time during purchasing decisions (Boden *et al.*, 2020).

The smart mirror finds application in front-end activities, enabling customers to virtually try products on and obtain information on product availability, alternative sizes, and colours. It saves time and reduce information costs (Schultz and Gorlas, 2023), thus increasing the service quality and customer satisfaction during the product choice phase (Ogunjimi *et al.*, 2021).

Similarly, smart fitting rooms – employed in front-end activities – assist customers when trying clothes on, improving the in-store experience but also facilitating marketing activities, through cross-selling (e.g. proposing complementary products, such as garments that match those worn) and up-selling activities (e.g. incentivising the purchase of alternative similar products but with a higher margin) (Wong *et al.*, 2012).

Smart shopping carts assist shoppers in various ways. They may provide the exact location of items on a pre-entered list, suggest alternative products, display the running total of the price, and show information about discounted items on nearby shelves. This makes them valuable for enhancing in-store customer experience and optimising store and marketing activities due to the information on shoppers' path (Roy *et al.*, 2017).

Lastly, sensors collect data about what happens inside the store, offering insights into the effectiveness of activities, such as marketing ones (e.g. measuring customer conversion rates, as done in online channels) (Epstein *et al.*, 2021).

4. Discussion

The analysis of the literature provided detailed insights into technology applications and their associated benefits. However, there are issues that deserve further investigation, discussed in the following paragraphs according to the presented categories, and summarised in Table 4.

	Present research	Future research
Technologies	Mainly focus on the most consolidated technologies	Focus on the newest technologies
Application area	Focus on the impact of technologies on conventional in-store retail tasks	i. Focus on the impact of technologies on post-sale activities ii. Focus on the transformation of the activities reshaped collaboratively with the involvement of customers and retailers
Perspective	Focus on the benefits enabled by the usage of technologies within the store and perceived by customers and retailers	i. Focus on the benefits enabled by the increasing integration of online and offline channels due to technology adoption ii. Focus on the benefits perceived by the employees

Source(s): Authors' own work

Table 4. Future research directions across technologies, application area and perspective categories

Considering *technologies*, their appearance in academic publications aligns with industry trends. The earliest interest towards smart technologies adoption for retailing emerged in the early 2000s, when the RFId – already widely used for supply chain traceability – was introduced in retail store settings, for inventory management optimisation purpose (Larson *et al.*, 2005; Rekik *et al.*, 2008). Consequently, earlier research focused on this technology. Starting from the late 2000s, SSTs began reshaping retail with the introduction of self-checkout kiosks and automated customer service systems, capturing the attention of the research community (Weijters *et al.*, 2007; Kaushik and Rahman, 2015).

The most significant research activity occurred from 2017 onwards, coinciding with the widespread adoption of innovative digital technologies like smart shelves, Artificial Intelligence, and Augmented Reality. This academic interest reflects the integration of various technologies in the late 2010s, reshaping the modern retail experience (Inman and Nikolova, 2017; Pillai *et al.*, 2020; Rejeb *et al.*, 2023).

Therefore, there is a clear imbalance of studies between the most consolidated ones (i.e. RFId and SSTs) and the newest ones (as shown in Table 2). Thus, academic contributions aimed at pointing out the major drivers and barriers of adoption, also related to privacy concerns, as well as investment analysis, would be useful, to both increase academic comprehension and guide retailers in technology assimilation process.

It is clear that technologies hold significant potential across various *application areas* and activities, offering opportunities to enhance both efficiency and effectiveness (Rekik *et al.*, 2008; Hardgrave *et al.*, 2013; Tu and Piramuthu, 2022), as well as improving customer experiences and operational outcomes (Wong *et al.*, 2012; Fiestas and Tuzovic, 2021; Liang *et al.*, 2022).

However, two main aspects are overlooked in the literature. First, there is a lack of attention towards post-sales activities, that can still be enhanced through the adoption of digital technologies, such as facilitating items return.

Second, the focus predominantly revolves around the potential impact of technologies on conventional in-store tasks. Moving further, a disruptive use of technologies can lead to a transformation of the activities by collaboratively reimagining and constructing them, with active involvement from both customers and retailers.

Addressing the *perspective*, the assimilation of digital technology within retail stores offers a multitude of advantages for both customers and retailers, resulting in a more personalised, interactive, and integrated shopping experience for consumers (Roy *et al.*, 2017; Hoehle *et al.*, 2018; Chang and Chen, 2021). Simultaneously, it equips retailers with the necessary tools to streamline operations, enhance customer relationships, and stay competitive in the ever-evolving retail industry (Zhou and Piramuthu, 2013; Landmark and Sjøbakk, 2017; Epstein *et al.*, 2021). In a broader context, these technologies enable customers and retailers to tap into the advantages commonly associated with online shopping (Jocevski, 2020; Zhang *et al.*, 2022). Therefore, future advancements in research in this field should prioritise increased integration of online and offline channels, suggesting how to create a seamless and more customised retail experience for consumers while optimising operations for retailers.

On top of that, the perspective of employees is often overlooked. Yet, the increasing presence of technology in stores significantly impacts employees' roles, necessitating the acquisition of new skills to both operate the technology and assist customers with it. Thus, research in these areas is essential.

In a greater detail, considering the *benefits* entailed by technology adoption in the various application domains, in some cases they can extend beyond the areas listed in Table 3. For instance, interactive fitting rooms can facilitate omnichannel behaviours, allowing customers to browse for different colours or sizes of the items tried on and buy them online. Retailers can gain insights about customers' preferences by comparing data from smart fitting rooms and purchase data. Smart shopping carts can collect customer path data, useful information to re-organise the store layout to both maximise profits and improve the experience. Even well-established technologies can find new uses, such as SSTs for in-store product returns, reducing customer wait times at checkout counters.

Expanding upon these examples, and with reference to Table 3, Table 5 presents some proposals for potential areas of further exploration. Specifically, Table 5 comprises two types of content. Grey-text cells report the content already presented in Table 3, necessary for contextualising new research directions. Blue-text cells, on the other hand, denote potential benefits achievable through the adoption of discussed technologies but that have not been addressed in the reviewed literature. These aspects can serve as subjects for future research.

5. Conclusion

In this paper, 103 articles addressing in-store technology adoption published in Q1 journals between 2005 and 2023 were reviewed. The contributions were analysed based on their content, according to three main dimensions: technology, application area and perspective.

Table 5. Areas for further research in the technology – application area matrix (blue text)

TECHNOLOGY	APPLICATION AREA: Back-end					Front-end					
	Inventory management	Price management	Demand management	Customer relationship management	Store layout management	In-store marketing activities	Information delivery	In-store customer experience	Product choice	Check-out	Post-sale activities
RFId	Improved accuracy (Rekik *et al.*, 2008; Rekik *et al.*, 2009; Hardgrave *et al.*, 2013); Reduced ticket switching occurence occurrence (Tu and Piramuthu, 2022); Higher stock visibility (Morenza-Cinos *et al.*, 2019); Improved replenishment activities (Condea *et al.*, 2012; Thiesse and Buckel, 2015); Contrast to counterfeiting and theft (Bhattacharya *et al.*, 2010; Zhou and Piramuthu, 2013)	Improved pricing policies (Zhou *et al.*, 2009)	Better customer knowledge (Landmark and Sjøbakk, 2017)			Increase in sale due to cross and up selling activities (Wong *et al.*, 2012)				Speed-up of the activity (Kasiri *et al.*, 2012) Save employee labour (Kasiri *et al.*, 2012)	
Self-Service Technologies										Speed-up of the activity (Lee, 2015; Demoulin and Djelassi, 2016; Fernandes and Pedroso, 2017; Duarte *et al.*, 2022)	Facilitate item returns
Augmented Reality						Increase in advertising effectiveness (Rejeb *et al.*, 2023; Zimmermann *et al.*, 2022)	Higher quality of information (Hilken *et al.*, 2018; Sung *et al.*, 2021)	Increase in customer enjoyment of the experience (Hilken *et al.*, 2018; Farah et al., 2019; Hollebeek et al., 2020) Foster store loyalty (Hilken *et al.*, 2018)	Reduced rate of returns (Perannagari and Chakrabarti, 2019)		
Virtual Reality											
Mobile device						Improved and personalised promotions (Schrage *et al.*, 2022)	Higher quality of information gathered online (Schrage *et al.*, 2022; Inman and Nikolova, 2017; Fiestas and Tuzovic, 2021)			Seamless payment experience (Taylor, 2016; Liang *et al.*, 2022)	Facilitate item returns
Artificial Intelligence	Inventory optimisation (Cao, 2021)	Improved pricing policies (Cao, 2021)	Better customer knowledge (Cao, 2021)			Improved and personalised promotions (Pillai *et al.*, 2020; Cao, 2021)		Increase in customer enjoyment of the experience (Pillai *et al.*, 2020; Cao, 2021; Sung *et al.*, 2021)		Seamless payment experience (Pillai *et al.*, 2020; Cao, 2021)	
Internet of Things	Inventory optimisation (Caro and Sadr, 2019)					Improved and personalised promotions	Higher quality of information (Balaji and Roy,				

(*continued*)

							(Balaji and Roy, 2017; Fagerstrøm *et al.*, 2020) Improved and personalised promotions (Caro and Sadr, 2019)	2017; Fagerstrøm *et al.*, 2020)				
Interactive display						Increase in advertising effectiveness (Willems *et al.*, 2017; van Giesen and Leenheer, 2019)	Higher quality of information (Willems *et al.*, 2017; van Giesen and Leenheer, 2019)	Increase in customer enjoyment of the experience (Willems *et al.*, 2017; van Giesen and Leenheer, 2019)		Seamless payment experience (van de Sanden et al., 2022).	
Robot	Higher stock visibility (Morenza-Cinos *et al.*, 2019).						Help in finding product and personalised product advice (Song and Kim, 2022)			Seamless payment experience (Song and Kim, 2022)	Facilitate item returns
Beacon						Increase in advertising effectiveness (Inman and Nikolova, 2017; van de Sanden *et al.*, 2019; Lin, 2022)	Higher quality of information (van de Sanden *et al.*, 2019)	Increase in customer enjoyment of the experience (van de Sanden *et al.*, 2019)			
NFC											
Smart shelf	Improved replenishment activties and improved accuracy (Inman and Nikolova, 2017)	Improved pricing policies (Inman and Nikolova, 2017)				Increase in advertising effectiveness (Inman & Nikolova, 2017)	Higher quality of information gathered online (Boden *et al.*, 2020)				
Smart mirror									Speed-up of the activity (Ogunjimi *et al.*, 2021) Reduction of information cost (Schultz and Gorlas, 2023)		
Smart fitting rooms			Better customer knowledge			Increase in sale due to cross and up selling activities (Wong *et al.*, 2012)	Search for products in online catalogue		Speed-up of the activity (Wong *et al.*, 2012)	Speed-up of the activity	
Smart shopping cart					Improved layout based on customers' path	Improved and personalised promotions (Roy *et al.*, 2017)	Higher quality of information (Roy *et al.*, 2017)	Increase in customer enjoyment of the experience (Roy *et al.*, 2017)		Speed-up of the activity	
Sensor				Conversion rate measurement (Epstein *et al.*, 2021)			Higher quality of information (Hoehle *et al.*, 2018)				

Source(s): Table by authors

Table 5.

More in detail, each of the identified dimensions was intended to answer the first three research questions. Indeed, the technology category provided an overview of the main smart technologies that could be used in retail stores and their definition (RQ1). The application area identified the process impacted by technology adoption (RQ2). While the perspective pointed out the main beneficiaries of technology adoption (RQ3). The crossing of these three dimensions allowed to answer RQ4, by illustrating the benefits – and who perceives them – stemming from the usage of each technology. The extant body of knowledge was accordingly presented, discussed, and summarised.

5.1 Theoretical implications

The present research contributes to theory in several ways. First, it enriches the academic conversation on the implications of technology assimilation in physical retailing (Grewal *et al.*, 2017, 2021; Mostaghel *et al.*, 2022). It systematises the existing fragmented body of knowledge, offering a comprehensive view of the topic by detailing the characteristics of various technologies and their benefits to in-store processes, as outlined in Table 3. It addresses a gap in the literature (Mishra *et al.*, 2021) and contributes to the research branch that investigates in-store processes (Rekik *et al.*, 2008; Wong *et al.*, 2012; Hardgrave *et al.*, 2013; Taylor *et al.*, 2019; Ogunjimi *et al.*, 2021; Tu and Piramuthu, 2022).

Second, it expands upon previous literature reviews that focused on specific technologies (van de Sanden *et al.*, 2019; Cao, 2021; Cavalinhos *et al.*, 2021; Xi and Hamari, 2021; Rejeb *et al.*, 2023), or particular aspects of the store experience enhanced by technology (Willems *et al.*, 2017; Szabó-Szentgróti *et al.*, 2023; Lahmeyer and Roemer, 2024).

Third, besides organising the existing literature on in-store technology adoption, the proposed framework can also serve as basis for studies in retail research at large, offering a unified and comprehensive approach for future investigations concerning retail stores.

Fourth, the research discusses past contributions on the topic, highlighting existing gaps and proposing directions for future studies in this field, accordingly, as outlined in Table 4 and Table 5.

Fifth, this research contributes to the consumer behaviour orientation theory (Babin *et al.*, 1994), by highlighting that technology adoption in stores significantly enhances customer satisfaction in both utilitarian and hedonic terms.

5.2 Managerial implications

This study provides insightful guidance for retail managers, especially those in the initiation stage of their technology assimilation journey (Zhu *et al.*, 2006), as it presents a comprehensive list of the main technologies suitable for in-store application (*what*) and their respective maturity levels. It also outlines the main processes for which these technologies are suitable (*where*), the primary beneficiaries of their adoption (*who*), and the benefits they offer (*why*).

Having a thorough overview of technology impact on in-store processes, retail managers can use this framework to guide their decisions. They should first define the advantages they seek to achieve and then select technologies that align with these goals. Nonetheless, as detailed in Table 3, each technology offers various benefits across multiple domains. Therefore, retailers should broaden their understanding to fully appreciate and utilise the extensive possibilities each technology provides.

Furthermore, technologies enable the seamless integration with online channels, thus retailers should leverage these opportunities, as outlined by the grey cells in Table 3. This approach will broaden their scope and allow them to reap the benefits typically associated with online channels.

5.3 Limitations and future developments

The limitation of this study pertains to the criteria employed for paper selection.

To begin with, certain digital technologies may have been inadvertently overlooked during the initial keyword search, potentially due to their limited awareness and understanding within the field. Furthermore, the decision to restrict the scope to papers published in Q1 journals may have excluded pertinent contributions from diverse sources. Nevertheless, the authors are confident that the included articles provide a representative and up-to-date overview of the research theme, and that the insights and the conclusions are trustworthy and reliable.

Second, the decision to focus on in-store technology adoption excluded contributions dealing with technology suitable for online retailing. Although this paper provides an initial look at some technologies that facilitate connections with online channels, future research could exclusively and thoroughly explore the processes unique to online retailing and the benefits of technology assimilation in that context.

Future developments of this work could broaden the focus on the timing aspect, delving into *when* retailers should strategically consider adopting technologies to ensure alignment with their objectives. Indeed, factors such as market trends, customer readiness, and competitive dynamics influence the optimal timing for technology assimilation. Examining these factors will guide retailers in making informed decisions, maximising the potential benefits while minimising risks.

Additionally, further developments of this research could focus on specific industries, such as fashion or grocery, considering their distinct characteristics and needs, thus providing tailored insights and address industry-specific challenges and opportunities.

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