Aisle be Back: State-of-the-Art Adoption of Retail Service Robots in Brick-and-Mortar Retail

Research Paper

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Abstract. Facing acute staff shortages, brick-and-mortar (B&M) retailers increasingly rely on technology to sustain operations. Retail service robots (RSR) promise to fundamentally transform retail. However, a holistic overview of their adoption remains elusive. Employing a dual research design, we take upon a task-specific perspective to synthesize the state-of-the-art adoption of embodied RSR in B&M retail. Findings indicate that RSR are predominantly adopted for information exchange and goods transportation, significantly enhancing customer service and operational efficiency. Nevertheless, opportunities for more enhanced communicative and anthropomorphic interaction with customers have not been leveraged yet. We therefore contribute to the theoretical understanding of RSR adoption by providing researchers and B&M retailers alike with valuable insights on the state-of-the-art of RSR adoption. As a result, we establish an illustrative foundation for future research and derive adoption gaps, which B&M retailers could leverage to advance RSR development and enable broader RSR adoption.

Keywords: Retail Service Robot, Brick-and-Mortar, Technology Adoption, Artificial Intelligence, Automation.

1 Introduction

Retail – a sub-sector of the service industry (Kotler, 1991) – constitutes a major sector worldwide in the interface between business and society. For instance, in the European Union (EU) retail encompasses approximately 5.5 million retailers generating over 1.4 trillion Euros in gross value added (European Commission, 2025). With nearly 30 million employees, it represents the largest private employment sector in the EU, occupying a critical economic role, e.g., through the distribution of goods and services to roughly 450 million consumers who allocate about one-third of their household budgets to retailer's services (European Commission, 2025). Despite retailers' crucial role (Schütte and Weber, 2021), brick-and-mortar (B&M) retailers face major challenges that threaten both their operational effectiveness and efficiency. B&M retailers are not only fighting fierce competition from online retailers – leading to fewer customers visiting stores, rising operational costs, and tighter profit margins – but also confronting a shortage of available personnel due to demographic change (Adhi *et al.*, 2020; Wittenhagen, 2024). The growing difficulty in finding employees is not merely an economic

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burden through increased labor costs (Bernstein *et al.*, 2008), but a critical risk for day-to-day operations: without sufficient employees, essential service counters remain unattended and the execution of vital tasks (e.g., shelf stocking and customer assistance) are jeopardized (Mende, 2024; Sadeghi, 2024). In response to these challenges, B&M retailers are increasingly transforming their in-store value propositions by adopting new technologies, prominently artificial intelligence (AI) and robots (De Gauquier *et al.*, 2021; Haenlein and Kaplan, 2021), which have received growing attention from both research and practice (e.g., Shankar et al., 2021; Sindhwani et al., 2025). A recent advancement is that of 'retail service robots' (RSR). According to service literature, RSR hold transformative potential for revitalizing B&M retailing (e.g., Mende *et al.*, 2019; Meyer *et al.*, 2023). While RSR are well-established in Eastern countries (Grewal *et al.*, 2025), their adoption in Western countries varies significantly. However, RSR offer the potential to automate routine operational tasks thereby mitigating the impact of rising labor costs, finding suitable employees, and enhancing overall store efficiency (Bogue, 2019). Additionally, advanced robotic adoptions promise to fundamentally transform the customer experience by enabling personalized interactions (Riegger *et al.*, 2021), immersive shopping environments (Singh *et al.*, 2019), and enhanced shopping assistance (Haenlein and Kaplan, 2021), including targeted support for customers with physical limitations or disabilities (De Gauquier *et al.*, 2021). Despite RSR potential, literature is predominantly centered on online retailing (e.g., digital platforms, omni-channel strategies). Studies addressing B&M retail – while valuable – often focus on software solutions aimed at enhancing customer service (e.g., service apps; Wulfert *et al.*, 2019), rather than on the holistic integration of novel technologies into the retailers' core operational tasks. Moreover, while automation in wholesale logistics using non-customer-facing industrial robots is well explored (e.g., Prawira *et al.*, 2023), such research fails to capture the challenges of adopting RSR in B&M settings, where issues of human-robot interaction (HRI), RSR characteristics, and socio-technical dynamics (e.g., Kranzer *et al.*, 2023) for both employee and customer acceptance are yet underexplored (Amelia *et al.*, 2022).

Therefore, we systematically examine the state of physically embodied RSR adoption. Specifically, we take a task-specific perspective and pose the research question: *"What is the state-of-the-art on physically embodied RSR adoption in B&M retail in research and in which operational tasks are RSR adopted by European-based B&M retailers in practice?"* To answer this, we conduct a dual-method approach combining a systematic literature review (SLR) (Bandara *et al.*, 2015; Vom Brocke *et al.*, 2015) and a multi-case study (Eisenhardt, 1989; Yin, 2018), thereby bridging rigor and relevance while ensuring comprehensive coverage of literature and practice (Lee, 1999). Thus, we primarily contribute to research on technology adoption by systematically analyzing which tasks according to Schütte (2017) and Onnasch & Roesler (2021) can be performed by RSR. The remainder is structured as follows: First, we lay conceptual foundations guiding our research, focusing on characteristics of RSR and B&M retailer's operational tasks. Next, we outline our dual-method approach. Subsequently, we present our results detailing the state-of-the-art of embodied RSR adoption. Finally, we conclude with a discussion addressing key findings, limitations, and recommendations for avenues of future research.

2 RSR in Value-Creating B&M Retail Business Operations

Retailers serve as intermediaries, i.e., "independent, profit-maximizing economic agent[s] mediating between two market sides" (Wigand, 2020, p. 40). Both B&M and online retailers establish economic legitimacy by efficiently mitigating spatial, temporal, quantitative, and qualitative distances between producers and consumers (Schütte and Weber, 2021). In contrast to online retailers, B&M retailers possess the distinctive advantage of engaging customers directly through experiential interactions within physical retail environments. Nevertheless, B&M retailers must carefully balance customer experience with operational efficiency (El-Manstrly *et al.*, 2024). We focus specifically on B&M retailers, which facilitate a range of tasks from a fixed location (e.g., boutique, department store) to private household consumers. Following Schütte (2017), these tasks can be illustrated using a generic retail information system shell model (see Fig. 1).

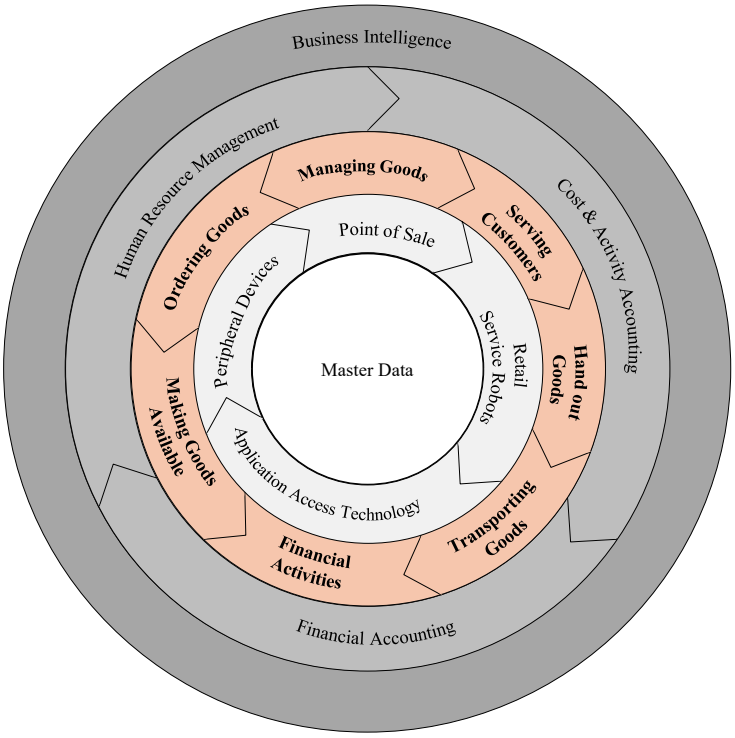

Fig. 1. Tasks and Processes in B&M Retailing (adapted from Schütte (2017))

From the inside out, the shell model consists of (1) master data (e.g., business partner, items, conditions, etc.), serving as a foundation for subsequent layers; (2) technical tasks mapped on master data; (3) economic-operative tasks that generate value and customer satisfaction, analogous to Porter's (1985) primary activities; (4) administrative

tasks (i.e., secondary activities; Porter, 1985); and (5) decision-oriented tasks providing information and recommendations to facilitate decision-making (Schütte, 2017). We specifically focus on the third layer – the economic-operative tasks – because these tasks directly contribute to value creation and customer satisfaction in B&M retail (Porter, 1985; Reinartz *et al.*, 2019). Following Weber & Schütte (2019, p. 265), these tasks include *managing goods*, encompassing strategic trade marketing based on the composition and control of the marketing mix (McCarthy, 1960; 4Ps: product, price, place, promotion; Constantinides, 2006); *ordering goods*, involving store replenishment to keep shelves filled; *serving customers*, covering customer advisory, transaction processing, and complaint handling; *transporting goods*, comprising logistics management, store warehousing, and shelf-space management; *handing out goods*, ensuring accurate, timely fulfillment of customer orders; *making goods available*, including planning, receiving, quality control, storage, and returns management; and *financial activities*, such as invoice handling, verification, discrepancy resolution, and settlement processes. These tasks are referred to hereinafter as retail-specific tasks.

Given the manual and labor-intensive nature of these tasks and in light of the mentioned challenges (Bogue, 2009), B&M retailers are progressively adopting RSR to enhance customer experiences and automate retail-specific tasks. Since these tasks are both directly and indirectly linked with customer touchpoints (e.g., store presentation, customer interaction), B&M retailers are increasingly shifting "from a traditional face-to-face [interaction] to a technology-enriched one" (Pantano *et al.*, 2017, p. 89). While RSR lack a uniform definition, they are defined in the literature, for example, as "system-based autonomous and adaptable interfaces that interact, communicate and deliver service to an organization's customers" (Wirtz *et al.*, 2018, p. 909). We focus on physically embodied RSR capable of performing tasks traditionally carried out by B&M employees. Unlike non-physical RSR (e.g., chatbots), RSR are understood as tangible (often AI-based or humanoid) machines equipped to navigate physical store environments and execute tasks involving direct (customer-facing) or indirect (non-customer-facing) activities, whereas the latter includes cleaning, shelf management, or re-stocking, thereby indirectly enhancing customer experiences by reducing out-of-stock (OoS) quotas and improving store presentation (Wirtz *et al.*, 2018). Unlike Wirtz et al. (2018), however, our understanding explicitly includes RSR in the range from fully autonomous to remote controlled (Onnasch and Roesler, 2021) as well as humanoid RSR characterized by anthropomorphic attributes such as facial features or musculoskeletal structures (Mende *et al.*, 2019; Song and Kim, 2022). In addition to the retail-specific tasks by Schütte (2017) and given the diversity of RSR and the lack of incorporating HRI characteristics in service research, we draw on the task dimension of the HRI taxonomy by Onnasch & Roesler (2021) to differentiate RSR along multiple task specifications, which include information exchange, precision tasks, physical load reduction, transportation, manipulation, cognitive, emotional, and physical stimulation.

3 Scientific Approach

We employ a dual-research method (see Fig. 2) to provide a theoretically grounded yet practically relevant overview of embodied RSR adoption in B&M retail.

Systematic Literature Review (Bandara et al., 2015, vom Brocke et al., 2015)

Conceptualization

Retail, Brick-and-Mortar

Robot*, Application*, Case Study, Adoption

("retail" OR "brick-and-mortar") AND "robot*" AND ("application*" OR "case study" OR "adoption") *in titles, abstracts, and keywords*

Selection

	Scopus	ebscoHost	IEEE	WoS	ACM
Initial	344	68	57	116	5
Language	340	66	57	116	5
Source Type	225	27	53	116	5
Duplicates	258				
Tit-Key-Abst.	129		26		103
Full Text	**46**				

Analysis

Data Synthesis	**Author-centric** and **deductive synthesis** (Webster & Watson, 2002) of embodied RSR adoption in B&M retail, drawing on retail-specific tasks (Schütte, 2017) and the HRI task dimension (Onnasch & Roesler, 2021).

Complementary Multi-Case Study (Eisenhardt, 1989; Yin, 2018)

	Ahold Delhaize	Tesco	Edeka Group	Rewe Group	LVMH	Schwarz Group	IKEA
Founded	2016	1919	1907	1927	1987	1930	1943
Country Orig.	Netherlands	UK	Germany	Germany	France	Germany	Sweden
# Employees	388,000[2]	333,890[2]	410,700[1]	389,270[1]	215,000[2]	155,000[1]	216,000[2]
# Stores	7,765[2]	4,506[2]	11,048[1]	15,718[1]	6,307[2]	1,530[1]	700[2]
*Annual Rev.**	89.36[2]	73.16[2]	70.71[1]	92.31[1]	84.68[2]	34.20[1]	45.10[2]

Note. *Annual revenue in billion €; [1] fiscal year 2023; [2] fiscal year 2024.

Fig. 2. Research Design Following a Dual-Method Approach

By combining an SLR (Bandara *et al.*, 2015; Vom Brocke *et al.*, 2015) with complementary case evidence from practice through a multi-case study (Eisenhardt, 1989; Yin, 2018), we bridge – at least in part – insights from research and practice to provide a more holistic state-of-the-art on embodied RSR adoption in B&M retail. Regarding the SLR, we initially conceptualized relevant search terms, synonyms, and homonyms in

an iterative review approach (Tranfield *et al.*, 2003). The SLR was conducted in February 2025 by searching in titles, abstracts, and keywords within appropriate academic databases (see Fig. 2; Gusenbauer and Haddaway, 2020), leading to *590 identified articles*. Duplicates as well as articles not written in German or English or published in peer-reviewed academic conferences/journals were excluded (as recommended by Kraus *et al.*, 2020), leaving *258 articles*. Two independent authors assessed their suitability in a two-stage content screening process (Kitchenham and Brereton, 2013) and categorized articles into three groups: Green (clearly relevant), Yellow (unclear relevance), and Red (irrelevant) (see Bettinelli *et al.*, 2022). First, two independent authors screened the titles and abstracts of the 258 articles for inclusion, which led to *103 green-*, *26 yellow-*, and *129 red-articles*. We adopted a positive approach, meaning any article whose relevance was unclear advanced to the second screening stage. Second, the same two independent authors analyzed the full texts of the remaining *129 articles* (i.e., yellow- and green-articles) to evaluate their appropriateness to the research question and the scope of the SLR. In both stages, we included articles explicitly addressing robotics in B&M retail settings, focusing on RSR use cases at the store level, and involving physically embodied robots. We excluded the following articles: articles without a focus on robotic use cases, articles focusing solely on wholesale or industrial contexts, and software-only robotic adoptions lacking physical embodiment. We did not discriminate based on the research method. In both stages, discrepancies and uncertainties were collaboratively discussed with the author team to ensure a shared understanding and consensus. This process led to the final sample of *46 relevant articles*. For analysis, we adopt an author-centric and deductive approach (Webster and Watson, 2002), mapping adopted RSR to retailers retail-specific tasks (Schütte, 2017) and Onnasch & Roesler's (2021) HRI task dimension.

Additionally, we conducted a multi-case study (Yin, 2018) to complement our literature-based mappings with illustrative empirical evidence from real-world RSR adoptions by B&M retailers. The multi-case study is well suited to bridge – at least in part – the research-practice gap through the investigation of real-world RSR adoptions, thereby addressing the "comparative lack of practitioner voice" (Bartunek and Rynes, 2014, p. 1188). We employed purposeful sampling (Bouncken *et al.*, 2025), targeting information-rich cases within the B&M retail sector that (1) had adopted RSR, (2) offered sufficient publicly accessible information, and (3) ranked among the largest European-based retailers according to Deloitte (2023). The rationale for focusing on large retailers lies in their substantial financial and operational resources, which increase the likelihood of investment in innovative technologies such as RSR. Consequently, we initially examined the 10 largest European-based B&M retailers and conducted an iterative search on the internet for indications of past or present RSR adoptions. In detail, we adopted a multi-source data collection and triangulation strategy, integrating primary and secondary data to enhance robustness and mitigate potential bias in public data (Eisenhardt and Graebner, 2007; Yin, 2018). We iteratively gathered and analyzed the cases' press releases and further information on the internet (e.g., corporate websites) as well as information from practice-oriented retail outlets (e.g., Lebensmittelzeitung) to gain detailed contextual insights into RSR adoptions. In this process, we

identified seven B&M retailers with documented RSR use and sufficient data availability to allow for in-depth analysis (see Fig. 2; ALDI, E.Leclerc, and Intermarché were excluded due to insufficient information). Data were collected iteratively by two authors and cross-validated across sources to confirm the scope and context of RSR adoption within each case. For analysis, two authors collaboratively structured, triangulated, and mapped the empirical insights on RSR adoptions to retail-specific tasks (Schütte, 2017) and the HRI task dimension by Onnasch and Roesler (2021). This iterative process continued until a point of subjective analytical depth was reached (i.e., further information on RSR adoptions no longer yielded substantially new insights). The resulting mappings were iteratively refined through discussions, and cross-source validation, and were incorporated into the results as illustrative examples.

4 State-of-the-Art Adoption of RSR in B&M Retail

The literature corpus (46 articles; author-centric mapping available on request from the authors) spans articles from 2009 to 2025 (see Fig. 3), with an observable increase in 2018, correlating with technological advancements and reduced costs of RSR technologies in the retail sector and the first academic conference focused on retail robotics and AI (Bogue, 2019). Notably, 22 articles (48%) were published in conference proceedings while 24 articles (52%) were published in journals. Quantitative research methodologies (58.7%) dominate the corpus (qualitative: 28.3%; mixed-method: 13%).

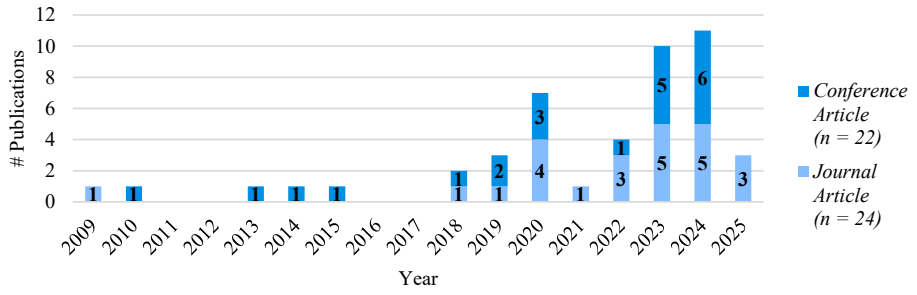

Fig. 3. Publications per Year and Publication Type

In total, 19 unique robots were analyzed 'TurtleBot' (4) and 'Pepper' (4) appearing most frequently. Pepper – an RSR by SoftBank Robotics – is a humanoid robot approximately 1.20 meters tall, equipped with cameras, microphones, sensors, and capabilities for speech, facial, and emotional recognition, and interactive communication via an integrated tablet (Grewal *et al.*, 2020). TurtleBot is characterized as an inexpensive mobile robot, that benefits from open-source software components (Singh *et al.*, 2019). Our task-specific analysis (see Tab. 1) indicates RSR adoption primarily for *serving customers* (28), *information exchange* (22), and *transport* (13). Conversely, no article addressed RSR adoption in financial activities and physical stimulation. Below, the results are structured according to the retail-specific tasks and linked to the HRI task dimension according to Onnasch and Roesler (2021).

Tab. 1. A Dyad Heatmap on RSR Task Specification in B&M Retail Operations

	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	∑
Managing Goods	1	0	0	0	0	0	0	0	1
Serving Customers	11 C_4	0	4	3	1	3	6 $C_{4,5}$	0	28
Hand out Goods	4 $C_{1,2,6}$	0	0	1	1	0	0	0	6
Transporting Goods	0	0	0	5	4	0	0	0	9
Making Goods Available	0	0	2	4	1	0	0	0	7
Ordering Goods	6 $C_{3,7}$	1 C_7	0	0	0	0	0	0	7
Financial Activities	0	0	0	0	0	0	0	0	0
∑	22	1	6	13	7	3	6	0	**58**

0 articles	*1 – 3 articles*	*4 – 6 articles*	*>6 articles*

Note. *The categorization is not mutually exclusive; T_1: information exchange; T_2: precision; T_3: physical load reduction; T_4: transport; T_5: manipulation; T_6: cognitive stimulation; T_7: emotional stimulation; T_8: physical stimulation; C_1: Ahold Dehaize; C_2: Tesco; C_3: Edeka Group; C_4: Rewe Group; C_5: LVMH; C_6: Schwarz Group; C_7: IKEA.*

Managing Goods: The management of goods includes, among other aspects of the marketing mix, product placement, for which retail companies provide planograms for their B&M stores. Planograms contain information about the desired state of a shelf, i.e., at which position which product should be positioned on a shelf. A mobile RSR can be used for checking compliance with planograms by exchanging information between robots and humans (T_1). The robot is equipped with computer vision capabilities and can therefore capture products on a shelf, process them as images, and thus reconstruct the entire shelf, which can be used by store associates for comparison with the planogram (Merabet *et al.*, 2024). By ensuring compliance with planograms, B&M retailers can optimize product placements, e.g., by drawing conclusions about the impact of different placements on their sales figures.

Serving Customers: Customer experience can also be improved through the adoption of RSR. The music playing in a store is an important factor in creating a pleasant atmosphere. An RSR with a robotic arm can be used to adjust the music depending on the background noise and can thus positively stimulate customers emotionally (T_7; Savery and Sukkar, 2024). A novel use case in a New York Louis Vuitton store featured an RSR embodying Japanese artist Yayoi Kusama to paint her signature artworks on the storefront window (The Art Newspaper, 2023). Furthermore, the robot Pepper can be used to greet customers, playfully provide information, or announce promotions to create a good shopping experience (T_1, T_6; De Gauquier *et al.*, 2021). Several RSR can cooperate to entertain customers in the best possible way. The so-called "wingman-leader recommendation" suggests placing one robot in front of the store and one robot inside the store (T_1, T_6, T_7; Song *et al.*, 2024, p. 2273). The robot placed in front of the store mainly tries to generate attention and advertisement for the robot placed in the store and thereby provides cognitive stimulation for customers. For instance, when a customer is guided to the robot placed in the store, an RSR can offer customers further information on products. Therefore, RSR can be used not only to exchange information

with store associates (see *Managing Goods*) but also with customers. For instance, the German grocery retailer REWE places a robot at the store entrance to attract attention and help customers. The RSR can dance, greet customers, and guide customers in search for a product to the corresponding shelf (Rosbach, 2025). A good customer experience also involves the cleanliness and hygiene of a store. RSR can manipulate its physical environment and be used to automatically clean the store floor and even disinfect floors (T_5; Choudhary *et al.*, 2024). Moreover, further customer advisory services may be enhanced through RSR support. In defining the roles of robotic service representatives in B&M retail, involving store associates is essential, as they are better equipped than robot developers to understand customer needs and appropriate responses (T_1; Vaziri *et al.*, 2020; Golchinfar *et al.*, 2023). In addition, RSR are utilized as receptionists in department stores to navigate customers to different stores (T_1; Vongbunyong *et al.*, 2024). In order to offer customers improved shopping convenience and assist customers with mobility impairments, RSR are utilized as self-driving shopping carts, such as 'wGo' or 'InBOT', whereby customers experience physical load reduction. By following the customer throughout the shopping trip and transporting products, the robot eliminates the need to push the shopping cart (T_3, T_4; Göller *et al.*, 2009; Neves *et al.*, 2019). The robots can be equipped with additional functionalities, such as support for product search or payment functions (Rancati and Maggioni, 2023; Patel *et al.*, 2024). Simultaneously, the risk of spreading viruses is reduced by avoiding touching the handle of the shopping cart. Moreover, the robot can return to defined locations in the store autonomously, eliminating the need for store associates to retrieve trolleys manually (Ramzan *et al.*, 2023).

Hand out Goods: Avoiding OoS situations represents a major challenge for retailers and at the same time a high risk of profit losses. As manually monitoring shelves in retail stores is time-consuming and therefore labor-intensive, these activities are often not repeated frequently enough. Therefore, OoS situations can occur quickly, especially with fast-moving consumer goods, potentially leading to lower customer satisfaction and customer churn. Hence, RSR (e.g., TurtleBot2, MetaBot) are utilized to recognize OoS situations and inform store associates immediately to replenish the missing products (T_1; Francis *et al.*, 2013; Kumar *et al.*, 2014; Kejriwal *et al.*, 2015). Especially in narrow aisles, it is essential that customers remain undisturbed while shopping, underscoring the need for adaptive interaction designs with RSR during regular working hours (Lewandowski *et al.*, 2020). Dutch supermarket chain Ahold Delhaize was one of the first retailers to adopt an RSR for B&M OoS monitoring. The robot 'Marty' is responsible for scanning the shelves in the store to detect OoS situations (Doering, 2019). Likewise, the German grocery retailer Kaufland – a subsidiary of the Schwarz Group – is currently testing two robots for OoS monitoring and the identification of misplaced products (Giuri, 2024). To prevent theft-induced stock depletion, Tesco deployed RSR capable of emitting loud deterrent sounds for security measures. For instance, when a potential break-in is detected, the RSR alerts the store manager within 47 seconds (Hargan, 2024). Moreover, the dispensing of goods to customers can be automated with RSR. For example, an RSR with a robotic arm can be used to serve coffee or dispense tobacco at a petrol station (T_5; Au-Yong-Oliveira *et al.*, 2020). RSR can also be used to dispense medicines in more complex contexts such as pharmacies.

Specifically, RSR are utilized to check whether a medicine is suitable for a customer's medical issue or to search for a specific product on a shelf (T_1, T_4; Basile *et al.*, 2024).

Transporting Goods: There are still only a few solutions for transporting goods from the store warehouse to the shelf. Nonetheless, it is a highly relevant issue for retailers, as the cost of B&M logistics can compromise the highest proportion of total operational costs (Kuhn and Sternbeck, 2013). A promising approach involves employing RSR that interact with the store's database systems. Upon a customer's checkout payment, the RSR is notified to transport a sold-out product from the warehouse onto the shelf at the shopfloor for re-stocking (T_4, T_5; Rahman *et al.*, 2022). Consequently, RSR can be used to transport products and manipulate its physical environment not only in interaction with customers (see *Serving Customers*), but also with store associates. However, re-stocking shelves is technically challenging due to different product sizes and weights, as well as the frequently occurring mixed pallets, rendering it difficult to pick a product (Bormann *et al.*, 2019; Hajj-Ahmad *et al.*, 2023; Mronga *et al.*, 2024). As a feasible first step, RSR can deliver products from the back store to defined locations in the store, saving store associates time (Qizilbash *et al.*, 2023).

Making Goods Available: Currently, depalletizing is often still exclusively carried out manually, whereby store associates are subject to heavy physical strain, for example in the case of a beverage market. In addition, the pallets often arrive at the store in non-standardized packaging or crates, creating technical challenges concerning gripping a single product (Fontanelli *et al.*, 2020). RSR can be used for depalletizing, reducing the physical workload of store associates and rendering the transportation of products from incoming goods to the shopfloor more efficient (T_3, T_4; Caccavale *et al.*, 2020; Völk *et al.*, 2023). Additionally, order picking in store warehouses, driven by services such as 'click and collect', remains a predominantly manual and time-consuming process. Automated guided vehicles are employed to automate this process by physically relieving store associates and increasing process efficiency simultaneously (T_3, T_4, T_5; Koreis *et al.*, 2025).

Ordering Goods: Real-time inventory awareness is key for effective stock management in B&M retail, although manual stocktaking remains indispensable yet error-prone (Casamayor-Pujol *et al.*, 2020). Several RSR are utilized to support inventory management, where precise localization of goods is necessary (T_1, T_2; Tripicchio et al., 2024), especially for large B&M retailing (Wu *et al.*, 2023). For this purpose, technologies such as radio-frequency identification (RFID) (e.g., Stockbot) and camera systems are employed in RSR (Rahman *et al.*, 2022). RFID technology does not necessarily require optical visibility, as the radio waves can pass any non-conductive material, allowing multiple RFID tags to be monitored simultaneously, thereby reducing the time required for inventory management (Motroni *et al.*, 2018; Bernardini *et al.*, 2022). Moreover, the German retailer Edeka has transparent real-time information regarding the inventory in its fully automated 'E24/7' store. Customers order products either via an app or a terminal in the store. After that, the RSR picks the ordered goods from the shelves and delivers them to the customer within the store (KNAPP AG, 2023). Another example from practice is the Swedish furniture retailer IKEA, which uses drones outside of opening hours to monitor stock levels in its stores (Van der Hoeven, 2023).

5 Discussion

One key finding of our study is that more unique adoption scenarios were identified in the literature review with a focus on customer rather than employee interactions, with most RSR adoptions found in customer service tasks. In some articles, the effects of different characteristics and appearances of robots on customers are examined (Grewal et al., 2020; Neves et al., 2019). Little consideration is given to the interaction of robots with employees in terms of acceptance. Another key finding is that many articles merely develop prototypes and test them in laboratory environments in terms of quantitative metrics. Experiments in the real world predominantly take place over a very short period and in just one type of retail store (e.g., Vaziri *et al.*, 2020; De Gauquier *et al.*, 2021). This, however, precludes drawing generalizable conclusions about the heterogeneous landscape of B&M retailing (e.g., due to varying product offerings). Furthermore, the novelty effect may bias acceptance by both employees and customers. In addition, we examined real-world RSR adoptions from leading European-based B&M retailers. We found that while many retailers discuss plans for RSR adoption or concrete adoptions in warehouses, few report on B&M store deployments – particularly in customer service. When they do, they keep information on a rather high level of abstraction. This may reflect a strategic effort to secure competitive advantage or indicate that, despite recent advancements in AI (especially generative AI; Banh and Strobel, 2023) and RSR, their adoption in B&M retail remains in its early stages. This also indicates that there are still barriers to the use of RSR in practice, which consist of organizational (e.g., skepticism from employees), political (e.g., uncertain development of regulatory efforts), and technological (e.g., difficulties with system integration) challenges, for example. Furthermore, publications from or about B&M retailers emphasize that RSR are intended to support rather than replace employees. This underlines the importance of developing RSR in collaboration with the domain experts on the shopfloor – the store associates.

The significance of our findings requires consideration of the limitations. Regarding the SLR, one limitation is the subjective selection of articles without the computation of interrater reliability scores (Lombard *et al.*, 2002) when screening the literature. Therefore, it is conceivable that relevant articles were incorrectly excluded based on a subjective assessment. In addition, only five scientific databases were considered, which – while appropriate (Gusenbauer and Haddaway, 2020) – may have resulted in the exclusion of other relevant articles. Regarding the multi-case study, we subjectively but purposefully selected cases and relied on publicly accessible information from retailers and news outlets, which are potentially biased. As we only examined the task-specific perspective, a notable limitation is the absence of consideration of other aspects affecting both employees and customers acceptance of RSR in B&M retail (e.g., the appearance or kind of HRI; Onnasch and Roesler, 2021). Consequently, we solely provide a task-specific state-of-the-art overview of RSR adoption in B&M retail as a foundation for further acceptance studies.

Recognizing the results and limitations, further insights into acceptance research are needed, which might be considered separately for store associates and customers, as how technology is accepted may be fundamentally different. For instance, employees

may be concerned about being replaced and therefore perceive the RSR adoption more negatively. Accordingly, examining differences in customer and employee acceptance of robot characteristics can enhance acceptance and HRI theory, potentially leading to the refinement of retail-specific tasks and novel emerging service opportunities through RSR. By incorporating the perspective of customers and employees alike, the application of models such as the Technology Acceptance Model (Davis, 1989), Unified Theory of Acceptance and Use of Technology (UTAUT; Venkatesh et al., 2003) as well as the extension UTAUT2 (Venkatesh *et al.*, 2012) become more complex and might be adapted accordingly. In addition, since the service dimension is currently not sufficiently considered in retail-specific task models, future research might address the differentiation of these tasks regarding service aspects. Moreover, future research might investigate the integration of large language models, that promise to offer great potential for humanizing RSR communication and thus potentially gaining greater acceptance among customers and employees (Strauss *et al.*, 2024). However, the extent to which an RSR with a more anthropomorphic appearance actually leads to a higher acceptance warrants consideration (i.e., uncanny valley effect; Vinoi et al., 2025). In addition to the barriers already mentioned, further contingency factors could be analyzed in greater depth (such as cultural aspects), which might have a strong impact on adoption depending on the scenario. Furthermore, we observed that in both literature and communications from practice, RSR are frequently deployed for narrowly defined, single-purpose tasks (e.g., cleaning stores). Therefore, future research could work on the development of multi-functional robots and investigate which tasks can be combined well. For example, it might be conceivable to build a robot that scans the shelves to recognize OoS scenarios, cleans the shopfloor when there are few customers in the store, and advises customers during peak times by helping them to find products. Moreover, the return on investment and the actual cost savings that can be achieved with RSR might be examined further, considering factors such as the effectiveness of RSR concerning different store sizes, products, domains, and layouts.

6 Conclusion

Current challenges in B&M retail are becoming ever more pressing as it is increasingly difficult to find a sufficient number of employees to ensure continued operation. At the same time, technological advancements in AI and RSR promise viable solutions. To address this, we applied a dual-method approach consisting of an SLR and a multi-case study to assess the status quo of RSR adoption in B&M retail. We discovered that RSR adoption is researched primarily for serving customers, information exchange, and transport. However, only a few RSR are adopted for serving customers in our B&M retail multi-case study. Therefore, our findings suggest that RSR adoption in B&M retail remains in its infancy, as they are commonly employed for narrowly defined, single-purpose tasks, not leveraging RSR full potential. Accordingly, there are still uncertainties and challenges, especially in the field of acceptance research, that hinder RSR adoption in B&M retail, offering fruitful avenues for future research.

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