In-store Technologies in the Retail Servicescape

Jan H. Betzing[1], Anh-Quoc Martin Hoang[1], and Jörg Becker[1]

[1] University of Muenster, ERCIS, Münster, Germany
{jan.betzing,martin.hoang,jorg.becker}@ercis.uni-muenster.de

Abstract. Brick-and-mortar retailers start to integrate digital in-store technologies into the physical servicescape to leverage individual shopping experiences for their customers and competitive advantage for them. This research provides a starting point for brick-and-mortar retailers, who lack guidance on how these technologies support their business strategies. We review the literature regarding the digital capabilities provided by customer-facing in-store technologies and identify their relations and contributions to the archetypal business strategies individualization and cost-optimization. We thereby extend the shopper-focused decision calculus by a technological view that relates the capabilities of in-store technologies, impacts on customers, and impacts on the retailers' business strategies.

Keywords: In-store Technology, Retailer-Consumer Interface, Brick-and-Mortar Retail, Business Strategy

1 Introduction

The digital era and the advent of omnichannel retailing transform consumers' shopping behavior in favor of digital channels and raise their expectations towards the digital profile of brick-and-mortar retailers [1–5]. Retailers react by integrating digital in-store technologies into the physical servicescape to leverage both the benefits of e-commerce such as multimedia product presentations, recommendations, and reviews and the benefits of the physical store such as personal service, touch and feel of the merchandise, and instant availability [5]. However, especially small and medium-sized retailers—without a large IT organization—that want to integrate these technologies into their business model can easily get lost by the variety of technologies to choose from and may lack a starting point for their assessments [2]. In consequence, they often select technologies without examining the potential contributions to their strategies [6].

Much research exists on the digitization of retail [e.g., 1, 5], the creation of digital shopping experiences [e.g., 3, 7], organizational changes related to in-store technology [e.g., 8], their acceptance by customers [e.g., 9], and the technologies itself [e.g., 2]. To date, there is—to the best of our knowledge—no attempt to provide retailers with a structured overview of the digital capabilities provided by contemporary customer-facing in-store technologies from a strategical point of view [6].

Consequently, our research goals are (1) to identify the digital capabilities that contemporary customer-facing in-store technologies provide to the retailer and (2) to identify their relations and contributions to the archetypal business strategies

Multikonferenz Wirtschaftsinformatik 2018,
March 06-09, 2018, Lüneburg, Germany

individualization and *cost-optimization*. These strategies build upon the theoretical lens of the shopper-focused decision calculus [6].

The remainder of this paper unfolds as follows: Section 2 gives the research background and strategic key concepts our analysis builds upon. Section 3 provides the applied research method. Section 4 presents the identified capabilities and shows their association to the key concepts. Section 5 links our findings to the shopper-focused decision calculus theory. Section 6 discusses our results and concludes this paper.

2 Research Background

The introduction of digital technologies in retailing is not a new phenomenon, dating back to the 1960s [1]. While previous advances such as Enterprise Resource Planning (ERP) mainly improved operational processes invisible to the customer, the nature of current developments is different. Self-service terminals, in-store assistants, and mobile payment are just a few examples that are directly visible to the customers. We define in-store technologies in retail as bundles of hard- and software that change or enhance the interface between retailers and customers within the physical retail setting. These technologies augment the servicescape by new customer touchpoints that facilitate technology-enhanced person-to-person, person-to-machine, and even machine-to-machine encounters [10]. Willems et al. remind us that "technology in retailing is and should remain a means to an end rather than an end in se" [2, p. 2]. Consequently, we take a retailer's perspective on the technologies' influence on his or her profit equitation. Primarily, the expected total benefits of ownership (TBO) must outweigh the total cost of ownership (TCO). The TBO depends on manifold internal (e.g., integration in the servicescape, organizational change) and external factors (e.g., customer acceptance, competition, obsolesce) and cannot be quantified in full. From a strategical point of view, benefits manifest in competitive advantage resulting from cost-optimization or differentiation through individualization [11]. The former aims at efficient operations whereas the latter aims at effective operations, which can be achieved by meeting customers' individual needs better than the competition, which in turn, positively affects revenue. The shopper-focused decision calculus theory argues in a similar vein [6]. Retail technology has the potential to decrease the retailers' costs and/or increase their revenue by extracting a consumer surplus, increasing the sales volume, attracting new customers or strengthening the retailer's bargaining power to suppliers [6]. The authors primarily focus on the customers' reactions to selected in-store technologies and treat the influences of retail technology to business strategy as a black box. This work contributes to the shopper-focused decision calculus by shedding light on this black box.

Since innovation cycles in customer-facing technology are fast, reviewing contemporary in-store technologies only reflects a snapshot in time. Therefore, we use generalized digital capabilities as abstract proxies for these technologies and show instances for clarity. In the context of our work, digital capabilities denote sets of features or services provided by an in-store technology and should not be confused with organizational capabilities in the sense of intangible assets known from the resource-based view. Digital capabilities can be used to classify future technologies and help to identify their merits. Against this background, our analysis of the capabilities and their relations focuses on the following two archetypal strategies:

1. *individualization* subsumes all contributions of in-store technologies to fulfilling the individual customer's needs effectively. Individualization revolves around establishing and maintaining a relation to the customer with the aim of increasing both the individual customer's basket size, and the overall number of customers. Further, differentiation through individualization aims at lowering the customer's opportunity cost, which manifests by either lowering the shopping effort or raising the shopping convenience.
2. *cost-optimization* subsumes all contributions of in-store technologies to fulfilling the retail operations efficiently. The primary goal of cost-optimization is to keep a certain service quality but decrease the retailer's cost through automation or offloading tasks to customers.

3 Research Method

The analysis performed in this work is based on the approaches for systematic literature reviews proposed by vom Brocke et al. [12] and Webster and Watson [13]. Following Cooper [14], we define the scope and goal of the review in identifying the digital capabilities that contemporary in-store technologies provide, and outlining their relations and contributions to the presented strategies. We focus on theoretical designs and practical applications of in-store technology w.r.t. the retailer-consumer interface. A search [13] across relevant journals and conference papers in information systems, computer science, marketing, and business administration was conducted on Scopus on 2017-06-18. Using Willems et al.'s inventory of customer-oriented retail technologies [2], we exploratively derived and refined our search query for various technologies and research streams related to in-store technology (cf. Figure 1).

```
TITLE-ABS-KEY ( ( "retail*" OR "sale*" ) AND ( "technolog*" ) AND ( "digital sign*" OR "assisted selling" OR "biometric*" OR "convenience" OR "interactive" OR "personal" OR "shelf allocation" OR "shelf manag*" OR "customer behavior*" OR "consumer behavior*" OR "recommend*" OR "pervasive" OR "customer preference*" OR "consumer preference*" OR "advert*" OR "customer loyal*" OR "consumer loyal*" OR "customer retention" OR "consumer retention" OR "automati*" OR "self-service" OR "co-creation" OR "prosumption" OR "value co-creation" OR "purchase behavior*" ) ) AND DOCTYPE ( ar OR cp ) AND PUBYEAR > 2008 AND ( LIMIT-TO ( SUBJAREA , "COMP " ) OR LIMIT-TO ( SUBJAREA , "ENGI " ) OR LIMIT-TO ( SUBJAREA , "BUSI " ) OR LIMIT-TO ( SUBJAREA , "SOCI " ) OR LIMIT-TO ( SUBJAREA , "DECI " ) OR LIMIT-TO ( SUBJAREA , "MULT " ) )
```

Figure 1. Literature search query

Due to the speed of technological innovation, we limit the literature search to the last eight years. The initial search yielded 2,147 results, whose relevance was evaluated analyzing their titles and abstracts [12]. Based on the initial screening, 81 relevant publications were analyzed in detail. A one-level backward and forward search lead to 14 additional publications. The final literature sample consists of 95 publications.

Although this selection must be seen as representative excerpt, the abstract nature of the digital capabilities allows for a comprehensive view.

4 Digital Capabilities of In-store Technology

We conducted an exploratory analysis of the 95 identified documents[1]. Figure 2 provides an overview of the derived digital capabilities, grouped by their main strategic impact. Five capabilities each primarily account for individualization and cost optimization strategies. We additionally identified three capabilities related to the elicitation of the customer's context. The capabilities are not mutually exclusive, i.e., one technology can support multiple capabilities, and one capability can both support the individualization and cost optimization strategies. In the same way, the capabilities can be combined, with one enhancing the operations of the other. We detail out our findings in the following:

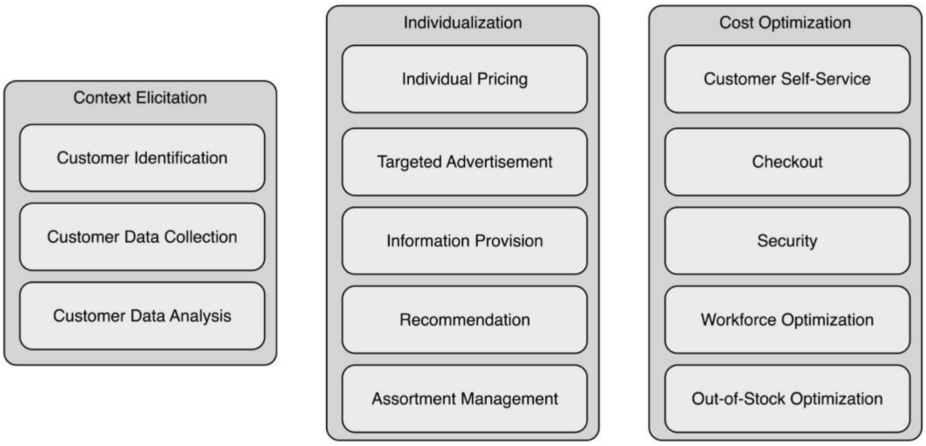

Figure 2. Digital capabilities provided by in-store technologies

Digital information on the customers and their shopping behaviors provide the foundation for most capabilities. Context elicitation, on the one hand, allows to approach the customer individually, and on the other hand to optimize overall store operations. Identification and data collection take place as soon as the customer enters the vicinity of the retailer [15]. Sensor- and vision-based technologies such as cameras, smart devices, wireless communication, and robots can be individually combined to personally identify the customer or at least individual traits, and his or her in-store shopping activities [16– 26]. Customers that already have a relation to the retailer can actively identify themselves at self-service terminals or the point of sale (PoS) using barcodes, QR-codes, loyalty cards, and NFC-equipped smart devices [20, 24].

[1] A concept matrix [13] that relates the literature to the digital capabilities presented in Figure 2 is available online at `https://goo.gl/yYufZU`.

Cameras with biometric face recognition capabilities that monitor the shop floor can identify inter alia the customer's gender, age, height, face, emotion, gestures, speech, and sentiment [21–23]. They also provide a feedback channel for digital customer touch points such as digital signage by monitoring the customer's interaction with the channel.

Sensor-equipped robots directly interact with the customers and adapt to their behavior w.r.t. the customer's reactions [17]. Interconnected robots can act cooperatively, e.g., outdoor robots interacting with pedestrians can inform in-store robots about potential customers entering the shop [18]. Manifold options exist to capture the customer's location and movement patterns using satellite navigation, Bluetooth-based beacons, WiFi, and cameras [18, 19, 25, 27]. RFID-tags (radio-frequency identification) can be attached to products [24], loyalty cards [20], and shopping carts [26], to track customers and their shopping baskets, purchases, and interaction with digital product information and the products itself [21, 28]. Vision-based systems identify, how long customers look at a product, if the product is picked up and bought or if it is placed back again [16, 29].

Customer data analysis generates insights from the collected information. Common approaches apply predictive analytics, data mining, and artificial intelligence to reason upon customer behavior [30–33]. Central insights on the individual customer level are the prediction of purchase behavior, i.e., the customer's willingness to pay and purchase probabilities for products [30, 32, 34] as well as the customer's preferences [35]. Aggregated information on movement patterns, hot spots, item popularity, interaction with digital touchpoints, and PoS data enable continuous improvement of the service delivery [36]. Both individual and aggregated insights set the foundation for the individualization and cost optimization capabilities.

Retailers having knowledge on the customer's willingness to pay and purchase probabilities can provide the customer with individual pricing, i.e., setting product prices that provide a good trade-off between maximizing the purchase probability and the extraction of customer surplus [11]. Individual prices are presented using digital signage, electronic shelf labels, self-service terminals, and mobile apps [24, 37]. Coupons, exclusive discounts, and individual product-service bundles are common means to achieve individual pricing [25]. Like how gas stations vary their prices over the day, retailers can exploit different price sensitivities over the day and automatically adjust their prices using electronic shelf labels [6].

Individual prices can be combined with targeted advertisement and product recommendations to create a tailored shopping experience [3, 7]. Digital signage, digital shopping carts, and self-service terminals that employ viewer analytics adapt to the current audience to display those advertisements to the customer that best fit his or her preferences and maximize purchase probability [38, 39]. Interaction can be initialized, once the customer directs his or her attention to the advertisement [40]. Forms of interaction include personalized messages, changing the display content following the picked-up item [21], sharing discounts [41], and downloading display content to a smart device [42]. Mobile shopping companion apps present current promotions, provide individual offers, create shopping lists, and manage the customer's loyalty status [25, 27]. Location-based push messages are a means to draw the customer's attention, e.g., informing the customer of promotions when standing close to the product in question [43]. Digital shopping carts allow changing their display content in accordance with the items in the cart [44], e.g., to recommend products that fit the current selection or to display additional information regarding the selected items.

The latter refers to the information provision capability, where retailers provide research-supporting shopping aids [45]. Extending the customer's information base increases the customer's convenience and its product research efficiency [11, 15]. Smart devices, digital signage, digital shopping carts, self-service terminals, and robots can give further product-related information (e.g., the number of stock left, product presentations, manuals, the origin of ingredients, the terms of warranty, and customer reviews) [17, 43, 46]. Product recommendations in the form of alternatives and complementary merchandise to the current product [47] can be presented in the same way to assist the customer in evaluating alternatives [15]. Applications of augmented reality such as smart mirrors, and virtual reality such as car simulators, allow trying products virtually [48, 49]. Smart mirrors can also suggest accessories matching the tried garments and recommend relevant products [48]. As with all instances of personalization, information on the customer's current and historical contexts must be considered [45].

Retailers leverage customer insights such as shopping paths, item view counts, and sales data to improve their offerings [47]. Assortment management is tasked with optimizing the range of offered goods and their placement. The goal is to maximize the product return on investment (ROI) w.r.t. shelf space allocation [33]. Popular items are placed along frequent shopping paths and complemented by related high-margin products to stimulate additional sales [28, 50].

In-store technologies are a means to introduce new services or replace the manual labor of existing services by automation [8, 45]. Information provision and recommendation capabilities are mainly aimed at increasing revenue, while the following instances of automating manual labor at the retailer-consumer interface are aimed at decreasing cost. Electronic shelf labels, for example, replace manual labeling [24]. They further help reducing potential spoilage and excess inventory by automatically adjusting prices w.r.t. nearing expiry dates [6].

Customer self-service using in-store terminals [39], smart devices [27, 43], and robotic service encounters [17, 18] replaces person-to-person encounters and lets the customer perform tasks of the retailer [10]. Self-service terminals and mobile apps are research-supporting aids, which improve the customer's knowledge such as the location of the product [45]. In-store navigation and way-finding is a crucial function of self-service because not finding merchandise is a primary reason for customers leaving the store [51]. Stationary touchpoints provide maps and directions [36, 39, 40], whereas mobile touchpoints directly navigate customers to the item in question [17, 46].

Self-checkout terminals already shift the checkout task to the customer. The consistent procedural nature of the checkout process holds further cost saving potentials from automation [52] by speeding up the payment transaction and scanning of items. Contactless payment using NFC-enabled cards or smart devices fastens the process over cash or card-based transactions that involve entering a PIN or signing [53].

Attaching RFID-tags to the items enables faster scanning of products compared to conventional methods such as barcodes [54, 55].

RFID-tags also double as an anti-theft security feature, rendering older electronic article surveillance tags obsolete [54]. Security also benefits from the customer identification, data collection, and customer analysis capabilities, which can aid security staff in identifying suspiciously behaving customers [56]. The current generation of cameras and RFID-tags fulfills multiple purposes such as customer and stock tracking [54, 57] as well as providing security features, rendering old systems obsolete, and thus abolishing the cost of maintaining multiple systems.

Aggregated information on in-store customer behavior also aids in workforce optimization [23]. Predictive analytics on the expected customer frequency are used to schedule employees more efficiently and to prevent queues to accumulate by constantly calculating the optimal number of registers [23, 52]. Like identifying suspicious behavior, video analysis supports staff in identifying customers in need of assistance [17]. Staff can interact with customers in technology-enhanced service encounters, in which employees use smart devices such as tablets, watches, and glasses to get information on the customer and the respective products [10].

Lastly, video- and sensor-based stock detection in the shelves enable live stock-level tracking and improved inventory management [48, 57, 58]. Staff can be notified in case of nearing or existing out-of-stock situations. Thiesse and Buckel show that the cost of RFID-based replenishment is offset by the performance benefits over periodic manual checks of the shelves [57]. Preventing out-of-stock situations mitigates lost sales and reduces customer dissatisfaction over unavailable merchandise [51].

5 Digital Capabilities in the Shopper-focused Decision Calculus

The shopper-focused decision calculus guides retailers regarding potential impacts of retail technology on shoppers and the retailer’s profits [6]. Drawing from equity theory, the authors empirically assess the customers’ perceptions and reactions to retail technology on retail patronage and word-of-mouth as mediators of technology adoption [6, p. 15]. However, the potential contributions of contemporary in-store technologies to the archetypal business strategies remain a black box. We presented digital capabilities of contemporary in-store technologies and now incorporate them into an enhanced form of the shopper-oriented decision calculus (see Figure 3).

In-store technology capabilities are divided into enabling and executing capabilities, whereas the former elicit the customer’s context either atomic on the individual customer level or aggregated on the store level. The latter is enabled and informed by the gained insights and execute the customer-facing services. In-store technologies themselves can be classified as context-aware if they can recognize and capture different situations using vision- or sensor-based technologies. Shopping-support systems influence the customer’s shopping process directly by interacting with the customer (e.g., recommender systems, shopping assistants) or indirectly by altering the store environment (e.g., digital signage, assortment management). In-store technologies can combine both enabling and executing capabilities and can be both context-aware and shopping-support systems.

The customer's perceptions mediate the potential influences of the capabilities on the archetypal strategies individualization and cost optimization. Following Inman and Nikolova's argumentation [6, p. 17,24], the acceptance of new technologies has an immediate impact on the retailer's profits. When customers, for example, do not adopt self-service terminals, their TCO are not offset by the realized TBO. Mediate effects are visible from customers altering their retail patronage. Good recommendations, for example, might lead customers to favor the service of the particular store over other stores, whereas negative experiences with in-store technologies might lead customers to choose a competitor in future. Similarly, customer word-of-mouth communication on their good and bad experiences moderates the impact of in-store technologies on the retailer's profit.

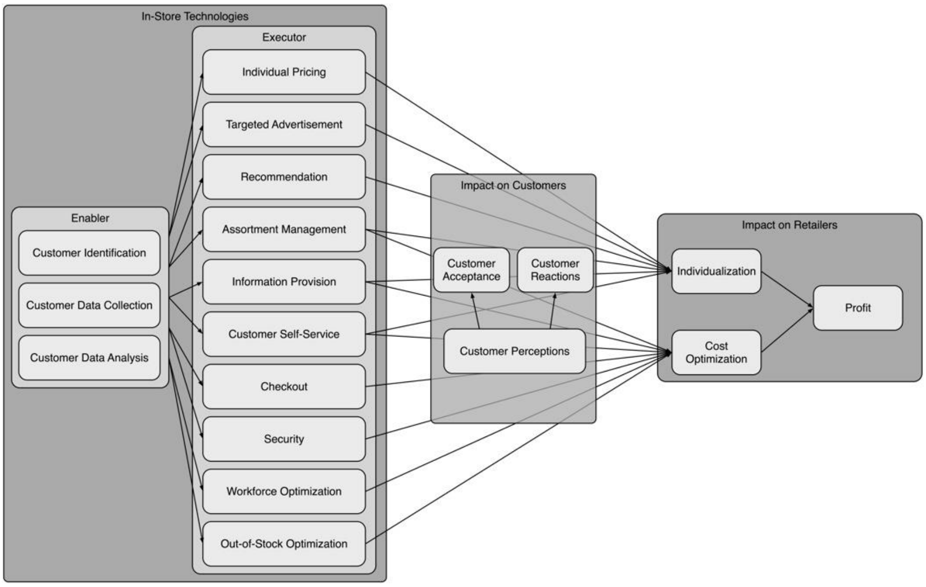

Figure 3. Augmented decision calculus

Individual pricing, targeted advertisements, and recommendations are essential capabilities for providing individual shopping experiences [7]. Research-supporting shopping aids [45] for information provision and customer self-service can both increase revenue through individualization and decrease cost by automating manual labor. Assortment management in a similar fashion increases revenue by optimizing the range and placement of offered goods, might improve customer satisfaction over better assortment, and decreases cost from excess inventory. Checkout, security, workforce optimization, and out-of-stock optimization are central capabilities to decrease cost by automating manual labor and by alleviating losses due to human mistakes, spoilage, theft, or employees being unproductive.

6 Discussion and Conclusion

We identified digital capabilities of in-store technologies and related them to the retailer's profit equitation. Our results serve as a starting point for retailers that want to adopt in- store technologies. The augmented decision calculus can become part of the sophisticated retailer's toolbox along other strategical lenses such as technology acceptance, investment management, and customer experience management.

Our results support the general assessment of new technologies but do not remove the need for a thorough evaluation of internal and external factors influencing the ROI. Retailers have to consider among other things the influence on different customer segments, organizational change [8], competitors, the sustainability of competitive advantage [11], and legal implications of context-aware technologies [43]. Moreover, the relevance and applicability of the individual technologies and capabilities depend among other things on the type of goods sold as well as the retailer's IT maturity and investment budget. Furthermore, the calculus does not consider the influence of an existing IT infrastructure on investment decisions and their profit implications. Future research can apply an integrative lens on the retailer's enterprise architecture regarding the integration, combination, and recombination of existing technologies to fulfill the capabilities. Since we abstract from particular instances of technology, we refrain from comparing the benefits and risks of individual technologies and do not attempt to rank or quantify their potential profit impacts. The digital capabilities are exploratively derived from contemporary literature on in-store technologies. We do not claim completeness of capabilities and ask other researchers to contribute and further extend our results. Moreover, is necessary to evaluate the augmented decision calculus in future research. We imagine conducting two-sided case studies, which validate the derived capabilities and hopefully provide support for their impact on the profit equitation. These results should be contrasted to surveyed customer perceptions, reactions, and measured adoption.

The speed of innovation urges especially small and medium-sized retailers, who are threatened by e-commerce, to continually assess new in-store technologies regarding their potential impact on profit and fit into their overall technological landscape. The presented set of digital capabilities supports retailers in understanding and classifying new technologies w.r.t. their contributions to the profit equitation. By incorporating the capabilities into the decision calculus, we provide retailers with a comprehensive tool for strategic thinking. Lastly, this research provides a comprehensive overview of contemporary in-store technologies for brick-and-mortar retail, which informs our overarching research project to design and evaluate technology-enabled service systems for co-creating digital customer experiences in brick-and-mortar retail.

Acknowledgments

This paper was developed in the research project *smartmarket*[2], which is funded by the German Federal Ministry of Education and Research (BMBF), promotion sign 02K15A074. We thank the Project Management Agency Karlsruhe (PTKA).

References

1. J. Hagberg, M. Sundstrom, and N. Egels-Zanden: The Digitalization of Retailing: an Exploratory Framework. Int. J. Retail Distrib. Manag. 44(6), 336–368 (2016)
2. K. Willems, A. Smolders, M. Brengman, et al.: The path-to-purchase is paved with digital opportunities: An inventory of shopper-oriented retail technologies. Technol. Forecast. Soc. Change 124, 228–242 (2017)
3. J. H. Betzing, D. Beverungen, J. Becker, et al.: Interactive Digital Customer Experience in High Street Retailing. HMD Praxis der Wirtschaftsinformatik 54(5), 659–671 (2017)
4. L. Bollweg, R. Lackes, M. Siepermann, et al.: Digitalization of Local Owner Operated Retail Outlets: The Role of the Perception of Competition and Customer Expectations. In: PACIS 2016 Proceedings. Paper 348. Chiayi, Taiwan (2016)
5. E. Brynjolfsson, Y. J. Hu, and M. S. Rahman: Competing in the Age of Omnichannel Retailing. MIT Sloan Manag. Rev. 54(4), 23–29 (2013)
6. J. J. Inman and H. Nikolova: Shopper-Facing Retail Technology: A Retailer Adoption Decision Framework Incorporating Shopper Attitudes and Privacy Concerns. J. Retail. 93(1), 7–28 (2017)
7. K. N. Lemon and P. C. Verhoef: Understanding Customer Experience and the Customer Journey. J. Mark. 80(6), 69–96 (2016)
8. E. Pantano and H. Timmermans: What is Smart for Retailing? Procedia Environ. Sci. 22, 101–107 (2014)
9. S. K. Roy, M. S. Balaji, S. Sadeque, et al.: Constituents and consequences of smart customer experience in retailing. Technol. Forecast. Soc. Change 124, 257–270 (2017)
10. R. J. Glushko: Seven Contexts for Service System Design. In: P. P. Maglio, C. A. Kieliszewski, and J. C. Spohrer (eds.) Handb. Serv. Sci., pp. 219–249. Springer (2010)
11. M. E. Porter: The Competitive Advantage: Creating and Sustaining Superior Performance. Free Press (1998)
12. J. Vom Brocke, A. Simons, B. Niehaves, et al.: Reconstructing the Giant: on the Importance of Rigour in Documenting the Literature Search Process. In: 17th Eur. Conf. Inf. Syst. pp. 2206–2217. ECIS ’09, Verona, Italy (2009)
13. J. Webster and R. T. Watson: Analyzing the Past to Prepare for the Future: Writing a Literature Review. MIS Q. 26(2), 13–23 (2002)
14. H. M. Cooper: Organizing knowledge syntheses: A taxonomy of literature reviews. Knowl. Soc. 1(1), 104–126 (1988)
15. W. D. Hoyer, D. J. MacInnis, and R. Pieters: Consumer behavior. Cengage Learning, 6 edn. (2012)
16. E. Frontoni, P. Raspa, A. Mancini, et al.: Customers’ Activity Recognition in Intelligent Retail Environments. In: Int. Conf. Image Anal. Process. pp. 509–516. Springer (2013)
17. F. Bertacchini, E. Bilotta, and P. Pantano: Shopping with a robotic companion. Comput. Human Behav. 77, 382–395 (2017)
18. K. Kamei, T. Ikeda, M. Shiomi, et al.: Cooperative customer navigation between robots outside and inside a retail shop—an implementation on the ubiquitous market platform. Ann. Telecommun. 67(7-8), 329–340 (2012)
19. A. Mancini, E. Frontoni, P. Zingaretti, et al.: Smart Vision System for Shelf Analysis in Intelligent Retail Environments. In: ASME/IEEE Int. Conf. Mechatron. Embed. Syst. Appl. Portland, OR, USA (2013)
20. T. H. S. Chu, F. C. P. Hui, and H. C. B. Chan: Smart Shopping System Using Social Vectors and RFID. In: Int. Multiconference Eng. Comput. Sci. vol. 1, pp. 239–244, IMECS ’13, Hong Kong (2013)

21. H. Hwangbo, Y. S. Kim, and K. J. Cha: Use of the Smart Store for Persuasive Marketing and Immersive Customer Experiences: A Case Study of Korean Apparel Enterprise. Mob. Inf. Syst. (2017)
22. R. Ravnik, F. Solina, and V. Zabkar: Modelling In-Store Consumer Behaviour Using Machine Learning and Digital Signage Audience Measurement Data. In: Int. Work. Video Anal. Audience Meas. Retail Digit. Signage. pp. 123–133, VAAM 2014, Stockholm, Sweden (2014)
23. T.-W. Lee, Y.-L. Chiu, Y.-S. Wu, et al.: An intelligent image-based customer analysis service. In: 16th Asia-Pacific Netw. Oper. Manag. Symp., pp. 1–4. APNOMS ’14, Hsinchu, Taiwan (2014)
24. W. Zhou, Y.-J. Tu, and S. Piramuthu: RFID-enabled item-level retail pricing. Decis. Support Syst. 48(1), 169–179 (2009)
25. Kam-Yiu Lam, J. K. Ng, and Jian-Tao Wang: A Business Model for Personalized Promotion Systems on Using WLAN Localization and NFC Techniques. In: 27th Int. Conf. Adv. Inf. Netw. Appl. Work. pp. 1129–1134. WAINA ’13, Barcelona, Spain (2013)
26. A. Karmouche and Y. Salih-Alj: Aisle-level scanning for pervasive RFID-based shopping applications. In: Int. Conf. Comput. Syst. Ind. Informatics, pp. 1–4. ICCSII ’12, Sharjah, United Arab Emirates (2012)
27. R. Pierdicca, D. Liciotti, M. Contigiani, et al.: Low cost embedded system for increasing retail environment intelligence. In: Int. Conf. Multimed. Expo Work. pp. 1–6. ICMEW ’15 Turin, Italy (2015)
28. S.-H. Huang, C.-Y. Tsai, and C.-C. Lo: A multi-data mining approach for shelf space optimization. In: 11th Int. Conf. E-bus. pp. 89–95. ICE-B ’14, Vienna, Austria (2014)
29. J. Liu, Y. Gu, and S. Kamijo: Customer behavior classification using surveillance camera for marketing. Multimed. Tools Appl. 76(5), 6595–6622 (2017)
30. P. Yan and D. D. Zeng: In-store Shopping Activity Modeling based on Decision-theoretic Dynamic Bayesian Networks. In: 19th Work. Inf. Technol. Syst. pp. 55–60. WITS ’09, Phoenix, AZ, USA (2009)
31. Y. Zuo and K. Yada: Using statistical learning theory for purchase behavior prediction via direct observation of in-store behavior. In: 2nd Asia-Pacific World Congr. Comput. Sci. Eng. pp. 1–6. APWC on CSE ’15, Nadi, Fiji (2015)
32. K. Kamei, K. Shinozawa, T. Ikeda, et al.: Recommendation from robots in a real-world retail shop. In: Int. Conf. Multimodal Interfaces. ICMI-MLMI ’10, Beijing, China (2010)
33. H.-B. Li, W. Wang, H.-W. Ding, et al.: Mining paths and transactions data to improve allocating commodity shelves in supermarket. In: Int. Conf. Serv. Oper. Logist. Informatics. pp. 102–106. SOLI ’12, Suzhou, China (2012)
34. T. Nakahara and K. Yada: Evaluation of the Shopping Path to Distinguish Customers Using a RFID Dataset. Int. J. Organ. Collect. Intell. 2(4), 1–14 (2011)
35. A. Ogino, T. Kobayashi, Y. Iida, et al.: Smart Store Understanding Consumer’s Preference through Behavior Logs. In: Int. Conf. Int. Des. Glob. Dev. pp. 385–392, IDGD 2011, Orlando, FL, USA (2011)
36. K. Mankodiya, R. Martins, J. Francis, et al.: Interactive Shopping Experience through Immersive Store Environments. In: Int. Conf. Des. User Exp. Usability. pp. 372–382, DUXU 2013, Las Vegas, NV, USA (2013)
37. S. Longo, E. Kovacs, J. Franke, et al.: Enriching shopping experiences with pervasive displays and smart things. In: Proc. 2013 ACM Conf. Pervasive ubiquitous Comput. Adjun. Publ. pp. 991–998. UbiComp ’13, Zürich, Switzerland (2013)

38. P. Tian, A. V. Sanjay, K. Chiranjeevi, et al.: Intelligent advertising framework for digital signage. In: 18th ACM SIGKDD Int. Conf. Knowl. Discov. data Min. pp. 1532–1535. KDD ’12, Beijing, China (2012)
39. C.-C. Chen: RFID-based intelligent shopping environment: a comprehensive evaluation framework with neural computing approach. Neural Comput. Appl. 25(7-8), 1685–1697 (2014)
40. J. S. Kim: A Study of Contact Frequency and Consumer Preference for Digital Signage Advertisement. In: Green and Smart Technology with Sensor Applications, pp. 181–187. Springer, Berlin, Heidelberg (2012)
41. A. Kaasinen and Y.-I. Yoon: Mobile advertising model in N-Screen environment for CSCW. In: 7th Int. Conf. Comput. Converg. Technol. pp. 140–143, ICCCT ’12, Seoul, Korea (2012)
42. J. S. Lee and K. Yoon: The application of digital signage system using smart device. In: 16th Int. Conf. Adv. Commun. Technol. pp. 675–677. ICACT ’14, Pyeongchang, Korea (2014)
43. M. Bourimi, G. Mau, S. Steinmann, et al.: A Privacy-Respecting Indoor Localization Approach for Identifying Shopper Paths by Using End-Users Mobile Devices. In: Eighth Int. Conf. Inf. Technol. New Gener. pp. 139–144. ITNG ’11, Las Vegas, NV, USA (2011)
44. T. R. Sheltami and E. M. Shakshuki: An efficient RFID solution to expedite services. In: 7th Int. Conf. Adv. Mob. Comput. Multimed. pp. 255–259, Kuala Lumpur, Malaysia (2009)
45. C.-c. Angela Chang and M. Kukar-Kinney: The effects of shopping aid usage on consumer purchase decision and decision satisfaction. Asia Pacific J. Mark. Logist. 23(5), 745–754 (2011)
46. M. Strohbach and M. Martin: Toward a Platform for Pervasive Display Applications in Retail Environments. IEEE Pervasive Comput. 10(2), 19–27 (2011)
47. F. E. Walter, S. Battiston, M. Yildirim, et al.: Moving recommender systems from on-line commerce to retail stores. Inf. Syst. E-bus. Manag. 10(3), 367–393 (2012)
48. J. Melià-Seguí, R. Pous, A. Carreras, et al.: Enhancing the shopping experience through RFID in an actual retail store. In: ACM Conf. Pervasive Ubiquitous Comput. Adjun. Publ. pp. 1029–1036. UbiComp ’13, Zürich, Switzerland (2013)
49. B. Begole, T. Matsumoto, W. Zhang, et al.: Designed to Fit: Challenges of Interaction Design for Clothes Fitting Room Technologies. In: Int. Conf. Human-Computer Interact. pp. 448–457. HCI ’09, San Diego, CA, USA (2009)
50. M. A. Syaekhoni, C. Lee, and Y. S. Kwon: Analyzing customer behavior from shopping path data using operation edit distance. Appl. Intell. pp. 1–21 (2016)
51. M. Stone: The death of personal service: Why retailers make consumers responsible for their own customer experience. J. Database Mark. Cust. Strateg. Manag. 18(4), 233–239 (2011)
52. P. Kumar: The competitive impact of service process improvement: Examining customers’ waiting experiences in retail markets. J. Retail. 81(3), 171–180 (2005)
53. M. Cocosila and H. Trabelsi: An integrated value-risk investigation of contactless mobile payments adoption. Electron. Commer. Res. Appl. 20, 159–170 (2016)
54. M. Hauser, C. Flath, D. Zügner, et al.: Pushing the limits of RFID: Empowering RFID-based Electronic Article Surveillance with Data Analytics Techniques. In: ICIS 2015 Proc. (2015)
55. M. Grabia: Assessment of effectiveness of the use of RFID technology in selected processes at DIY retail store. In: IEEE Int. Conf. RFID Technol. Appl. 134–140, Tokyo, Japan (2015)
56. Y.-k. Wu, H.-C. Wang, L.-C. Chang, et al.: Customer’s Flow Analysis in Physical Retail Store. Procedia Manuf. 3, 3506–3513 (2015)
57. F. Thiesse and T. Buckel: A comparison of RFID-based shelf replenishment policies in retail stores under suboptimal read rates. Int. J. Prod. Econ. 159, 126–136 (2015)
58. E. Frontoni, A. Mancini, P. Zingaretti, et al.: Information Management for Intelligent Retail Environment: The Shelf Detector System. Information 5(2), 255–271 (2014)