State-of-the-art and adoption of artificial intelligence in retailing

Felix Dominik Weber and Reinhard Schütte

Abstract
Purpose – In the most abstract way, artificial intelligence (AI) allows human work to be shifted toward technological systems that are currently not fully capable. Following this, the domain of retail can be sketched as a natural fit for the application of AI tools, which are known for their high proportion of human work and concurrent low profit margins. This paper aims to explore the current dissemination of the application of AI within the industry. The value-added core tasks of retail companies are examined to determine the possible utilization and the market adoption within the globally largest retail companies is given.

Design/methodology/approach – The paper uses two different approaches to identify the scientific state-of-the-art: a search on the major scientific databases and an empirical study of the ten largest international retail companies and their adoption of AI technologies in the domains of wholesale and retail.

Findings – The application within the different value-added core tasks varies greatly depending on the area. In summary, there are numerous possible applications in all areas. Especially, in areas where future forecasts are needed within the task areas (such as marketing or replenishment), the use of AI, today, is both scientifically and practically highly developed. In contrast, the market adoption of AI is highly variable. The pioneers have integrated extensive applications into everyday business, while the challengers are investing heavily in new initiatives. Some others, however, show neither active use nor any effort to adopt such technology.

Originality/value – To the best of the author’s knowledge, this is one of the first research contributions to analyze the areas of application and the impact of AI structured along the value-added core processes of retail companies.

Keywords Retail, Trade, Retailing, Artificial intelligence, Machine learning, Wholesaling
Paper type Research paper

1. Introduction
1.1 Wholesaling and retailing

In an economy based on the division of labor, trade has the task of balancing spatial, temporal, qualitative and quantitative distances between production and consumption. Trade comprises the activities of purchasing goods from various manufacturers or suppliers; transporting, stocking and combining the goods to form an assortment; and selling them to commercial (wholesaling) or non-commercial (retailing) customers without the goods being significantly modified or processed. The different kinds of retail can be differentiated generically between brick-and-mortar retailing (selling from a fixed location as a department store, boutique or kiosk), mail and distance selling or online trading.

To reasonably structure the analysis of the purpose and potential relevance for the wholesale and retail industry, this article focuses on a reference model to structure the main processes of a retailing company. Its overreaching structure will help to group and structurally report the findings within a domain relevant structure. The framework proposed as the reference model to describe a retail task is called the retail information system architecture shell model (Schütte, 2017). It contains, from the inside out, the master data as
a core, the technically machine-oriented, value-adding and the administrative and decision-oriented tasks of the retail company (Figure 1).

As the machine-oriented, administrative and decision-oriented tasks are rather generic and not elementarily different between retail companies, the following article concentrates on the value-added core tasks. Following the reference model, the main value-added tasks of retailing are summarized as managing goods, ordering goods, serving customers, handing out goods, transporting goods, making goods available and financial accounting activities (combining billing goods, accounts payable and receivable and auditing). In accordance with the initial architecture from Becker and Schütte (2004), the task areas can be recapped as including the following components.

Firstly, the management of goods is located in the scientific domain of trade marketing, which is defined as the processes of analysis, target formulation, strategy selection and the composition and control of the marketing mix in a trading enterprise (Borden, 1964; Haller, 2008). The central decisions that have to be made within the scope of trade marketing encompass the four areas of the marketing mix. The basis is the central concept of the 4Ps, introduced by McCarthy (1960), which structures the marketing into four separable (but interlinked) components, namely, “product,” “price,” “place” and “promotion.”

Figure 1 Retail information system architecture shell model (Schütte, 2017)
Ordering goods includes all activities related to restocking the stores, keeping the shelves filled and reacting to customer demands. Depending on the type of trade company, this covers the processes between central warehouses and the stores, between the suppliers and the warehouses and between the suppliers and the stores (if directly supplied).

Serving customers combines the tasks that are intuitively attributed to trade, such as the activities within the store including sales advice and the actual core activities at the cash desks. The operative tasks include the initiation, execution and downstream processes (customer service and complaint management) of a transaction.

The transport of goods and logistics entails any task related to storage and the removal of goods from storage. Thus, this involves any functions associated with the creation or management of the warehouse structure to stock transfer and warehouse management as a whole. This encloses the management of storage locations and shelf space optimization. It also contains the operational tasks of goods between the central warehouses to the individual stores, from the manufacturer to the stores in the direct goods business and the coordination of these activities.

Handing out goods (goods issue) includes tasks involved with fulfilling the order with the agreed quantity, quality and time. Starting from the delivery date, the goods must be picked up and delivered.

Making goods available or goods receipt is the functional field of activity ranging from planning, acceptance, control, returning and the physical storage of the goods and the parallel entry of these processes.

The financial accounting activities subsume all operational activities, such as invoice entry, invoice verification, deviation control, invoice post-processing and the settlement of subsequent remunerations.

1.2 Artificial intelligence for retailing

All efforts within the domain of information technologies, independently of an academically motivated and enforced separation of the research fields, followed the assumption and goal of the transfer of task to be overtaken by machines in the past decades. Artificial Intelligence (AI) was born out of the considerations regarding the extent to which the machine can partially or completely replace humans in the performance of tasks. McCarthy (1998) defines AI as “[…] the science and engineering of making intelligent machines, especially intelligent computer programs. It is related to the similar task of using computers to understand human intelligence, but AI does not have to confine itself to methods that are biologically observable.”

This paper in no way claims, nor will there be a need to discuss the concept of AI in its entirety or to address philosophical thoughts about intelligence itself (Turing, 1995). More than that, it is noted at this point that to evaluate the use of AI in trade, the ideas of Russell and Norvig (2016) will be followed: AI is the science, which teaches computers and machines actions that cannot yet be carried out by the computer and in which people are currently better at. The used methods in AI are not only exclusive to this discipline. Machine learning (ML) is a discipline within AI research that deals with learning improvement based on data. Ultimately, it is a matter of the extent to which tasks are continuously better solved by the machine by using particularly good training data or particularly large amounts of data from algorithms.

Following this short but colossal idea of AI, the next step is to evaluate the fields of application and possible impact in the trade domain. Here, we mainly concentrate on the underlying business tasks that are subject to the transfer toward the machine. The retail sector is characterized by an oligopolistic market with strong intra-competition between existing retailers and rising inter-competition between traditional and new “pure” digital
players in many countries (Schütte, 2017). With the looming market entry of Amazon with AmazonFresh, this competition is intensifying further. This increased competition, a warning scope for differentiation between operating types (Meffert et al., 2015), has increased costs and the overall increased price awareness (Daurer et al., 2012) and influence of the company’s price image on the customer’s choice for a retail chain; thus, there is a need for companies to stay competitive.

Due to the nature of the stationary retail (brick-and-mortar), in particular, the areas of work can be described as being focused on manual tasks done by people. This is reflected, above all, in the high personnel costs between 12 (grocery) and 40 per cent (bakery) involved in the total turnover (Glaeser, 2014). However, this does not only apply to operational activities in either direct or indirect customer contexts, but there has traditionally been a low level of use of technologies and analytics in retail. On the other hand, the operating margins are very low with an average of 0.1 per cent and a maximum of 3 per cent (Lorentschitsch, 2016).

Both aspects together, the relatively high personnel costs and use on the one hand and the low operating margins on the other, make the retail domain appear as the ideal industry for the application of AI and related technologies. Overall, there is enormous potential for the transfer of human activities to machines.

1.3 Research methodology

To identify relevant scientific journal articles that have dealt with the application of AI in wholesaling and retailing, we conducted a search on the major databases, namely, EBSCOhost, Google Scholar, JSTOR, ScienceDirect, SpringerLink and Wiley Online Library for a ten-year period (2008-2018) using combinations of keywords, namely, “Artificial Intelligence,” “retail,” “wholesaling,” “making goods available,” “ordering goods,” “managing goods,” “serving customers,” “handing out goods,” “billing goods,” “transporting goods” and “financial accounting” (and relevant synonyms). After this, an initial search through the databases was completed and 61 matching articles from a total 3,700 of were retrieved from different journals. Every article was carefully reviewed before it was incorporated into the literature review. A large number of publications could not be included because they primarily focused on manufacturing, logistics or related domains. To identify relevant practical applications, we conducted a search on the major English-speaking and retail-related newspapers and websites of the major retail associations, namely, the Retail Week, the National Retail Federation, the British Retail Consortium, Retail Focus Magazine and The Grocer. Here, we identified a total of 6,590 relevant articles. To give an overview about the market adoption for the worldwide retail industry, we analyzed the largest retail companies and their publicly announced AI initiatives and the applications already in use (Section 3).

2. Artificial intelligence for value-adding core tasks in retailing

2.1 Managing goods

The applications of AI within the tasks of managing goods are advanced. In particular, all tasks related to the marketing mix are, due to their analytical nature, well-suited for AI. In today’s society, both stationary retail and e-commerce are highly dynamic and as the market is changing rapidly, prices are too. Complex analyses and decisions in price management can be carried out with intelligent and self-learning solutions. Dynamic pricing (Kephart et al., 2000), as a new development, is a pricing strategy in which companies adjust prices for products or services in real-time based on the current market demand. This is a model that calculates prices using automatic algorithms, as human decisions would not cope with the required speed and amount of data to be considered (Jaekel, 2017).
For example, in rainy weather, hardly any grilled meat is bought; in contrast, less sushi is bought during cold conditions. However, simple relationships such as these have two problems. On the one hand, they are only available at very short notice, while production and supply chains are longer-term processes. On the other hand, they are relatively imprecise, so a large buffer, still, has to be included in the planning. Retailers and manufacturers of perishable goods need precise sales forecasts for their markdown management to sell off these products before their end of lifetime is reached (Kuo et al., 2002).

The factors on which quantity planning is based on are more complex than simple weather forecasts. Especially, because of the interactions of several factors, static models have previously not been precise enough. In particular, for to longer-term forecasts, they were at their limit. Building on AI-based methods, complex models can now also be used as a basis for sales forecasts (Efendigil et al., 2009; Lee et al., 2012; Guo et al., 2011).

AI is also used to customize the store layout to maximize customer satisfaction and sales opportunities (Newcomb, 2018).

The assortment of the entirety of all selected and offered goods of a retail company and the design of the assortment and its operational management and control are carried out within the scope of the assortment management. Here, AI assists with the selection of the right assortments for different stores and uses changes as user behavior changes (Leo Kumar, 2017).

Within omnichannel retailing, AI is also used to personalize the shopping experience with personalized searches, personalized recommenders or personalized prices and promotions (Montgomery and Smith, 2009).

2.2 Ordering goods

Replenishment optimization is a major field for AI application within retailing (Blue Yonder, 2017). The determination of the right time to place an order of the right quantity to the central warehouse and then to the suppliers can save massive costs for the retail and trade companies. With improvements at the inventory level (Šustrová, 2016), it is also possible to reduce unsold goods and enhance the cash flow (as inventory costs cannot be invested in new products). Another field of the application here is the optimization of shelf space (Landa-Silva et al., 2009) within the stores and the determination of an optimal base-stock level (Huh et al., 2009) so that the shelf always looks filled up and replenishment is not needed too often. AI algorithms can also optimize the order and delivery to individual customers (Boldt, 2017). An example of an application for environmental protection (and cost-saving) is used at Marks & Spencer. The retail chain uses AI during replenishment tasks to reduce waste (Weinbren, 2017). On the customer side, the optimization of the fulfillment processes (Ning et al., 2009) within the supply chain can be implemented with AI technologies. In particular, critical and massive complex tasks, such as coordinating and performing same day delivery (Kawa et al., 2018) to end customers, are made possible only by AI.

AI also supports the individualization aspect by allowing individual ordering for customers. This can include an individual in store ordering (Dennis, 2018b), for example, individually designed fashion items or systems for voice-enabled ordering (Dennis, 2018a).

2.3 Serving customers

A major application of AI within this task set is the replacement or automation of activities at the point of sales (POS). AI applications related to serving customers have particularly been developed for POS digitization, automation and advertising. Here, solutions are based on AI in connection with displays, language assistants and robots emerge. The most far-reaching
changes of current processes and tasks come with the application of AI in automated systems for self-checkout (Bertasius et al., 2016). A prominent example here is Amazon with its Amazon Go shop prototype (Rüschen and Wiehenbrauk, 2017). Staying more in line with the existing store concepts are robots, as used for sales assistance in Amazon Robotics, Ocado, Cisco or Softbank (Frangoul, 2017). At the customer interaction and service level, chatbots (Christie, 2018) and language assisted ordering (such as Amazon Echo) (Holmqvist et al., 2017) are relevant. In terms of interactive displays and digital signage, AI is used to advertise products from a store in a targeted manner, related to age, gender, emotions or objects detected in real-time on the body of a customer (Bauer et al., 2011). For example, the startup “the birds” and the hardware provider “Sensape” use large displays with a computer system with AI. This AI makes it possible to recognize the environment to allow interactive and intelligent advertising. Customers can even interact with these displays due to the incorporation of AI-based motion sensing (Chen et al., 2009). Security and fraud detection are a major issue within retailing. The retail industry has to compensate for nearly 1.3 per cent percent of their total turnover due to theft by customers and service employees. Sometimes, friends or family members of staff personnel manipulate barcodes with the knowledge of the cashiers or they stack goods on the conveyor belt cleverly, so that they are simply overlooked by the scanner (Welch et al., 1999). Innovative video cameras with AI-based algorithms analyze POS activity (Trinh et al., 2011; Kou et al., 2004) and give a warning to the store supervisor, who is then able to convict the employee of the fraud. AI-based video surveillance systems with image processing and recognition algorithms register at real-time speed when goods remain in the trolley and signal the checkout staff or the supervisor. Another major area of implementation for fraud detection systems based on AI is credit card and payment fraud (Delamaire et al., 2009; Phua et al., 2010).

In brick-and-mortar stores, virtual showrooms can leverage ML algorithms to customize the buying experience and virtual assistants can provide an interactive dialog between the customer and the retail organization (Syam and Sharma, 2018).

2.4 Transporting goods

Autonomous transport systems have existed in intralogistics for some time. These transport wagons travel on predefined routes through large warehouses from A to B. AI optimizes these autonomous systems by actively anticipating environmental situations (Pierdicca et al., 2015; Tarantilis and Kiranoudis, 2007) and looking for alternative routes, for example, in the event of a traffic jam during the loading or unloading of trucks (Wurman et al., 2008). At Amazon, for example, ML is used to select the ideal packaging size for each shipment (Stevens and Phillips, 2017). AI is also used to optimize how many items of each product should be kept in different warehouses, as this varies greatly depending on the warehouse, region, season and major cities nearby (Xu et al., 2017). The AI adjusts the optimal stock quantities accordingly. AI is used for delivery and shipping to manage last-minute changes. This includes selecting the best alternative port if the originally planned port is blocked, estimating the time of arrival and measuring the probability that a carrier will cancel a commission. IBM and The Weather Company use 100 TB of weather data per day to generate location-based weather forecasts and consider possible delays caused by storms, hurricanes and typhoons (Armstrong, 2017).

The use of AI in supplier management enables suppliers to adapt production plans to orders from the retail (Thomassey, 2010) and to identify suitable suppliers for the retail. This makes supplier selection more objective and subject to both qualitative and quantitative performance indicators with AI-based decision models that take various factors into account (Kuo et al., 2010) and go beyond the traditional role of pure price reduction (Ko et al., 2010). Also, AI can be used for decision support for management disruptions and the mitigation of risks in supply chains (Giannakis and Louis, 2011).
2.5 Handing out goods

Given the irregular order patterns, limited time for order processing and short-term delivery schedules (same-day or next-day) offered by e-retailers, which are now expected by customers, logistics providers must be extremely efficient in handling these orders and managing the whole fulfillment process (Leung et al., 2018).

AI systems can interactively monitor and optimize all logistics processes and even the products characteristics (size, shape and weight) and order demand factors can be considered during logistics strategy formulation (Lam et al., 2015).

Here, AI calculates the probability with which the trucks registered in the system are on a certain route, as well as the free capacities they offer and the tour cost. This is all possible in real-time and without the requirement for human interaction. At the same time, AI-powered systems constantly analyze hundreds of thousands of loads, take current events into account and learn independently how prices and time schedules are formed. AI technology makes the fulfillment processes more transparent, reliable and environmentally friendly. For example, Deutsche Post DHL Group built up a test fleet of autonomous and purely electric delivery vehicles that are controlled by an AI backend system that considers all relevant factors (delivery date, customer history, price offer, weather conditions, traffic and location specifics) to optimally plan the route for same day delivery and logistics between warehouses.

2.6 Making goods available

With the help of AI, supermarket shelves can be filled automatically by integrated shuttles. These shuttles transport the goods silently into a supply aisle that is directly integrated into the sales shelf. They are loaded via a replenishment area in the supermarket. This is located outside the sales room and is not visible to the customer. The shelf and replenishment area are connected by a connection network integrated directly under the ceiling of the sales room. A shuttle can also supply several shelves at the same time. The number of shuttles used depends on the size of the supermarket and the number of shelves. In addition, the shelf system is linked to the merchandise management system of the supermarket and the entire shelf stock is known. Thus, the system can determine the optimum replenishment volume and the optimum replenishment time per AI for each item. The start-up company “Tally” has developed a robot with AI for the retail trade that controls shelves fully automatically. The machine automatically searches for empty spaces or incorrectly stored products and travels through the shops fully automatically (Vanian, 2018).

If not already averted by AI (Kumar et al., 2014), e-commerce retailing must manage many small-scale returns: Products that are not returned properly and in their original packaging often do not have an article number. They are, therefore, posted manually to the system. However, this is only possible if it can be determined beyond any doubt which article is involved. Seasonally changing collections and strong similarities between individual pieces of fashion make it difficult to identify the right product. A search in the catalog takes a long time and is extremely error-prone. With the help of automatic image recognition, the catalog images available in the online shop can be compared with the returns. This allows the article number to be determined and the piece of fashion to be returned to the system. In practice, however, it has been shown that simple image matching is not sufficient; reflections of the glossy materials (jewelry), different perspectives and lighting conditions lead to errors in image recognition. This is where the AI’s potential – in concrete terms, artificial neural networks – comes into play.

2.7 Financial accounting

In the area of financial accounting, support by systems is well-advanced because of its naturally virtual characteristics. However, today, vast amounts of incoming financial data
(bills) are still not digitalized. So, the first field of application is the automatic reading and interpretation of documents by AI. Invoices and documents contain a large amount of data, such as invoice items and terms of payment. A software that uses AI learns to recognize and validate the relevant data independently based on ML and the thousands of previous inputs from experts (Suponenkovs et al., 2017; Arianto et al., 2017). Digital, paperless processes reduce costs and increase efficiency.

In the next step, systems are used to predict the account assignment with a high probability and fully automatic processing of all involved process steps. Using ML and based on previous entries made by financial experts or the input from experts, for example, tax consultants, such systems can make proposals for posting records and automation.

The reconciliation of account data and receipts, as well as the account assignment of bank information, is possible by using AI. The software accesses both data sources directly. Self-learning algorithms compare the document information with the transactions in the company’s bank accounts. This makes the process of bank reconciliation even more reliable compared to human review, and above all, it can be carried out daily or at any time.

With the use of AI, the financial accounting software used no longer serves to assist the accountant digitally, but rather handles the accounting largely autonomously.

This requires procedures with which invoices and receipts of all kinds can be recognized exactly, followed by automatic assignment to an account, payment clearance, detection of anomalies such as price deviations of individual articles and automatic postage of routine calculations and receipts. For systems that cover the full process from handling incoming documents to the final clearing, the software must not only be able to recognize what is available but also be able to deal with what is not or only approximately recognizable. This means it must be able to control blurriness and vagueness. This can be done using AI methods such as fuzzy logic.

3. Market adoption of artificial intelligence within retailing

To investigate the pioneers in the application of AI technologies, we studied the current and past AI initiatives of the ten largest retail companies ranked by their turnover in 2016 (EHI Retail Institute, 2016). To categorize the different types of companies, we followed the long-established research method, “the Magic Quadrant” (Figure 2), of the US market research
company Gartner (2017). Here, the objects of research are mapped on a two-dimensional matrix with four quadrants. Each quadrant represents a type of company in the market. Starting clockwise from the bottom left, these are niche players, challengers, leaders and visionaries. The market research version of the quadrant classes the objects based on the “completeness of vision” (X-axis) and the “ability to execute” (Y-axis). Gartner summarizes the former as variables such as the financial health of the supplier, market responsiveness, research and development, target markets and client base. In addition, the latter as the reflection of the innovation of the vendor: whether the vendor drives or follows the market or whether the vendor’s view of how the market will develop is consistent with Gartner’s viewpoint (Black and Thomas, 2014). Due to keeping the competitive advantage the company does not reveal the actual metrics behind the placement of a vendor or technology within a specific quadrant.

For the present research, an adaption of the initial approach is used. The horizontal axis of the matrix draws the applications that are already actively used in daily business and the vertical axis draws solutions or ideas that are planned, announced or under test operation. Niche players show little or no initiatives to integrate AI technologies into their existing business. They have no known cases of application in daily business operations and their ambitions are also extremely low. Challengers are companies with their first active applications in operation as lighthouse projects. For these market participants to be perceived as leading companies, however, they still have to work on a strong and convincing vision for the use of AI or communicate it publicly. Leaders not only have some applications that support their daily business but also refer to new ideas, commitment or research in the field of AI. Visionaries, unlike niche players, have active implementation ideas or first beta projects in progress. However, their number of applications in use is very low. To assign the companies and their activities to the quadrants a quantitative approach is followed. The further the placement on the axis is, the higher is the number of initiatives or prototypes found in the literature.

Walmart is a globally active US retail group and one of the world’s top-selling companies. As one of the pioneers, Walmart has recently launched a new AI software to the market. The intelligent system, called Eden, will enable employees to see how fresh the fruit and vegetables are and when they go bad. To do this, they have to photograph the fruits via an app. Based on the photo, the tool analyzes, to what percentage the fruit is damaged and how many days it can still be stored at the given storage temperature. The app is not only intended to provide fresh fruit and vegetables at Walmart but also intended to help Walmart optimize its supply chain. If bananas turn brown more quickly over long distances with fluctuating temperatures, they could, for example, be sold in stores closer to their place of origin. According to the US chain (Musani, 2018), the ML-based software is already used in 43 distribution centers.

Walmart and Microsoft have entered into a strategic partnership allowing the vendor to leverage Microsoft’s cloud platform and the company’s expertise in both ML and AI (Walton, 2018). Walmart also relies on AI in more remote areas. For example, Walmart recently patented pollinator drones and other autonomous agricultural aircraft. They are also supposed to monitor pests and spray pesticides. However, industry experts suspect that behind the sudden interest in agricultural drones, the company is attempting to compete with Amazon in the food sector by significantly reducing costs in the supply chain (Fischer, 2018).

Costco has no AI initiatives or applications in place or at least none have been publicly announced.

The Kroger (2017) company presented a $9bn plan called “Restock Kroger initiative” with the goal of building its e-commerce, digital and omnichannel businesses and “redefining the customer experience” at its annual shareholder meeting in 2017. Kroger
partnered with Nuro, a start-up that specializes in autonomous vehicles for delivery, on its pilot program (Meyer, 2018). Kroger has partnered with the online-only retailer Ocado to automate its warehouses and uses AI to optimize its bottom line. Ocado claims to have the world’s most sophisticated automated grocery warehouses and the two companies announced they will open three new warehouses that are run by robots and powered by ML algorithms to navigate and pick products (Vella, 2018). With “84.51,” Kroger has an in-house analytics and marketing company – this is a unique effort among the big retailers on its own. However, with “Kroger Precision Marketing,” it has access to a self-developed cross-channel media solution that is keen “to amplify the retailer’s personalized communication programs” (CGT, 2017) by focusing on ML (Davenport, 2018).

The German Schwarz Group is mainly known for its discount chain Lidl. For Lidl, the first step into the use of AI considers the fact that hardly anyone is familiar with wines and the choice of wine racks is often unreasonably high. Therefore, the discounter provides its customers with an AI-based consultant. This is a chatbot called “Margot,” who helps the customer in the choice of the noble drops. So far, however, this is only available in UK. Further application scenarios are not known (Christie, 2018).

The drugstore chain Walgreens offers a telemedicine application. Online consultation hours can be booked via the website and app of the pharmacy chain under the name “Find Care Now.” Walgreens has also integrated other telemedicine services and apps into its platform. Patients can receive dermatological advice via “DermatologistOnCall” or talk to a psychotherapist via “MDLive.” The app uses bot technology developed by Microsoft “to help triage patient inquiries before [patients] interact with a doctor via video” (Walgreens, 2018).

The tech and retail giant Amazon.com is probably the most advanced retailer in the field of AI application. Amazon has been investing heavily in the research and development of AI for years. ML algorithms are at the core of many of the internal systems. These AI systems are actively used in all products, from route optimization in the fulfillment centers and the recommendation engine (Linden et al., 2003) to Echo powered by Alexa, the Prime Air drone initiative and the new Amazon Go retail experience. With its cloud platform, AWS, it is even offering AI and especially, ML capabilities to third parties.

The Home Depot is the largest DIY retailer in the USA. The company mainly sells tools and construction equipment and offers services such as assembly and repair services. The company recently announced that it will increase its investment in big data, AI and ML by massively hiring new staff in this area (O’Shea, 2018). The Home Depot is using ML actively to predict shelf-out scenarios within stores.

**ALDI**, including the German discount retail chains ALDI Nord and ALDI Süd, has no publicly announced any AI initiatives in place.

France’s largest food retailer Carrefour is focusing on partnering with companies to include AI. The company announced that it is working on developing new services based on AI with Google (Agnew, 2018). Some more specific test projects with AI include a cooperation with Sirgul on a single store smart retail pilot centered around discovering the customer journey and leveraging devices with AI in Taiwan (Zabala, 2018) and with Blippar to leverage augmented reality and AI for image recognition in its app products (van den Oever, 2018).

CVS Health Corporation, an American pharmacy and healthcare company and Aetna announced their merger to offer a vertically integrated stack of services and touch points in health-care in 2017 (Dignan, 2017). The analytics company Aetna brings an analytics architecture and experience in fraud detection on insurance payments, alongside a massive data pool that could lead to more personalized medicine and predictive health services (Darin, 2018). CVS’ physical and digital retail footprint can then be used for the last mile services in healthcare. The track record of the innovations of different fields goes back to 2015 with the announcement of their “digital innovation lab” department and a
partnership with IBM to use IBM Watson’s AI application to predict which customers need interventions to avoid emergent health issues (Fastcompany, 2018).

4. Conclusion

In conclusion, there is a vast number of possible applications of AI in all areas of retail and wholesale. Within the different value-added core tasks, the numbers of conceivable applications (scientifically) and practical applications vary greatly (Table I).

Especially in areas where forecasts are needed within the task areas (such as marketing or replenishment), the use of AI today is both scientifically and practically highly developed. AI is particularly relevant to the area of decision support and analytics and is also used in practice. Due to the particular circumstances of the retailing domain, the number of obstacles faced by data analytics is particularly high.

For example, the huge assortment and fast succession of sales multiplied by the thousands of stores operating leads to a data volume that cannot be handled by humans. The absence of the necessity of analyzing this data in the past and the lack of the technical practicability (McAfee and Brynjolfsson, 2012; Litzinger, 2013) with most of the current retail information system architectures are the reasons why the priority within the domain of retailing for any analytics and machine-based decision automation has traditionally been low (Schütte and Vetter, 2017). Ultimately, the complexity, imposed by the interdependences between a huge amount of possible influencing factors, for example, the composition of the assortment, the placing within the store, the competition and their actions and the promotional activities or composite effects are major challenges as well. Here, AI (primarily ML) proposes a solution for solving these problems without the full knowledge of all relevant influencing factors.

| Table I | Overview of AI applications for the Value-adding core processes in retailing |
|-----------------|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|-----------------|-----------------|
| **Value-added core tasks of a retail company** | **Managing goods** | **Ordering goods** | **Serving customers** | **Transporting goods** | **Hand out goods** | **Making goods available** | **Financial accounting** |
| **AI application** | **Price management** | **Replenishment optimization** | **Replacement or automation of POS** | **Intralogistics** | **Same day delivery** | **Automated shelves** | **Automatic reading and interpretation** |
| **Forecasting** | **Inventory level** | **Customer interaction and service** | **Packaging** | **Route optimization** | **Vendor machines** | **An autonomous account assignment and processing** |
| **Store layout** | **Shelf Space optimization** | **Interactive displays and digital signage** | **Security and fraud detection** | **Storage layout and timing** | **Fulfillment strategy** | **Incoming goods** | **Automated reconciliation and decision-making** |
| **Location selection** | **Base-stock adjustment** | **Security and fraud detection** | **Packaging** | **Route optimization** | **Vendor machines** | **Automatic reading and interpretation** |
| **Assortment Planning** | **Optimal fulfillment** | **Virtual showrooms** | **Disorders** | **Supplier management** | | |
| **Marketing optimization** | **Same day delivery** | **Virtual assistants** | **Supplier management** | | | |
| **Markdown management** | **Ordering** | **Voice-enabled ordering** | **Supply chain optimization** | | | |
| **Placement** | **Voice-enabled ordering** | | **Supply chain risk management** | | | |
| **Personalization** | **Individualization** | | | | | |
A particularly small number of AI methods can be seen in the areas that interact directly with the customer. This, of course, is due to the stationary orientation of retailing. With the introduction of omnichannel-Commerce (as the integration and orchestration of cross-channel trading via the Internet), AI-related applications can certainly be observed, for example, chatbots that interact directly with the customer. The same low usage applies to all processes that are involved with the physical movement of products. Here, it is possible to use robots, but due to the aforementioned cost structure in the retail, this is not feasible or at least not financially viable for most companies. Only exotic realizations like Amazon’s checkout-free grocery store, “Amazon Go,” are notable exceptions.

The huge possibilities for both reducing the traditional high cost for human resources in retailing and optimizing the low margin business show the enormous, but not yet broadly realized, opportunities of the application of techniques and methods of AI in the retail industry.

Looking at the market adoption of AI within the biggest retail companies, the same pattern is observable. There are some pioneers (Amazon and Walmart) that have integrated extensive applications into everyday business and set AI as a main innovation and differentiation possibility for themselves. Some challengers, such as Walgreens or The Home Depot, seem to have followed this idea and are currently investing heavily in new initiatives, but have only a few applications in production. A lot of other retail companies, however, show neither any active use nor any efforts to invest in AI applications in the future. In the long term, and from a scientific standpoint, it will be intriguing to consider whether the financial and competitive success of the examined companies can somehow be related to early or late investment in AI technologies.

References


About the authors
Felix Dominik Weber is a PhD candidate at the Chair of Business Informatics and Integrated Information Systems with a research focus on digitization, artificial intelligence, price, promotion and assortment management, as well as transformation management. At the University of Duisburg-Essen, he is Head of the SAP University Innovation Lab and at the same time Consultant for SAP systems in (retail) trade and thus combines current practice with scientific research in these areas. Felix Dominik Weber is the corresponding author and can be contacted at: Felix.Weber@icb.uni-due.de

Reinhard Schütte is Professor for Business Informatics and Integrated Information Systems at the University of Duisburg-Essen, Germany. He got his PhD in Business Informatics from the University of Muenster, Germany. He is author for more than 100 publications in German and international journals and books. His research topics are (retail) enterprise systems, information modelling, enterprise transformation, effects and efficiency of IT systems and scientific theory. Beside his academic career, he served in different leading positions (CFO/ CIO, COO) in German retail companies and was responsible for a number of big software implementation projects. He is member of the scientific board of the Software AG, Germans second largest software company.

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