Research on Artificial Intelligence Technology Empowering New Retail: A Case Study of Unmanned Retail

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Abstract. The integration of cutting-edge technologies, such as artificial intelligence, into the commercial retail sector is revolutionizing traditional retail methods and supply chain processes. This study examines the impact of AI technology on the new retail landscape, including the growing trend of unmanned retail. This study begins by conducting a literature review to analyze the current state of new retail from a technological perspective. The research demonstrates that artificial intelligence technology is driving the advancement of new retail, supported by the "New Retail Wheel" theory and real-world examples. Next, the study examines the demands of unmanned retail and the crucial technologies that support its various business functions. Finally, the paper provides a case study of NBY to analyze the use of AI technology in its new retail operations and the resulting economic impact. The central artificial intelligence technology in the unmanned retail industry caters to the requirements of consumers, businesses, and society. The aim of this research paper is to serve as a guide for the implementation of AI technology in new retail ventures. A successful retail revolution and improvement can be attained when the pull of consumer demand and the drive of technology are in harmony.

Keywords: New retail · artificial intelligence · new retail wheel · unmanned retail

1 Introduction

Artificial Intelligence (AI) is a cutting-edge field of study that encompasses theories, methods, technologies, and application systems that aim to imitate, augment, and enhance human intelligence. Simply put, AI refers to the technology that replicates human intelligence through standard computer programs. The advancement of AI technology will bring about a radical transformation in human production and daily life. Tasks that are repetitive or require simple cognitive abilities, such as data sorting, proofreading, data entry, autonomous vehicle driving, and unmanned equipment control, will be fully replaced by AI technology, thus revolutionizing various industries including new retail.

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"New Retail" was first introduced by Jack Ma at the Yunqi Conference in Hangzhou in October 2016, and since then has received widespread attention from all sectors. The concept and implementation of New Retail align with China's economic transformation and upgrading in the current environment. As the economy undergoes fundamental changes, moving from a high-speed growth phase to a high-quality development phase, this marks a new standard, period, and stage of economic development.

At present, the prevalent formats of New Retail include unmanned retail (such as unmanned shelves and convenience stores), intelligent stores that integrate unmanned and manned operations, new fresh supermarkets, and new consumption experiences. The key factor is the application of new technologies, such as Artificial Intelligence, in the retail sector, completely transforming the traditional retail and distribution methods and providing limitless imagination and development opportunities in the digital era's new economy.

2 Literature Review

At present, scholars carry out research on the new retail field from the perspective of technology. Poncin, Mimoun (2014) [1] and Poushneh, Vasquez Parraga (2017) [2] both pointed out that many brick-and-mortar retailers rely on investment in technology or new retail formats to improve customer experience. Torabi, Hassini, and Jeihoonian (2015) build a model that meets the needs of online stores for fast and efficient distribution. The online order will be sent to the inventory center closest to the consumer. If the inventory center cannot meet the order demand, the information will be immediately sent to other retailers for restocking. Through the developed cross-integration program, retailers can significantly reduce costs and fulfill customer orders faster. This program is based on cloud computing and big data analysis technology [3]. Scholars such as Chou and others (2016) believe that an important challenge for retailers is to complete the digitalization of online and offline operations and realize the integration of mobile technology and service multi-channel [4]. Nukala et al. (2016) [5] and Hofmann (2017) [6] believe that grocery retailers will better meet the needs of customers by adopting digital technologies such as RFID technology and big data analysis technology. Du and Jiang (2017) believe that new retail enterprises should build an omnichannel retail platform to achieve smooth online and offline channels, and they also should pay attention to the application of digital technology, especially big data analysis technology [7]. Grewal, Roggeveen, Nordfalt (2017) summarized and analyzed the impact of big data, artificial intelligence, virtual reality and other technologies on the future retail industry, and pointed out that the development of artificial intelligence technology is an essential driving force for the development of the retail industry. Retailers use various technologies to serve customers, and artificial intelligence technology will help retailers make better decisions [8].

At present, most scholars' research on the field of unmanned retail is limited to its impact on traditional retail and its prospect analysis. Song Zipeng (2018) [9] and Feng Junwei (2018) [10] both analyzed the development prospects of unmanned retail. Jiang Lu (2018) [11] conducted research on the impact of unmanned retail on traditional retail.

Therefore, it is very necessary to study new retail from the technical level, and provide suggestions for the transformation and development of traditional retail enterprises and the entry of non-retail enterprises into this field.

3 AI Technology Empowers New Retail

3.1 The "Wheel of New Retail" Theory

The Japanese scholar Masao Nakanishi combines the development trend of the retail industry at that time and puts forward the theory of "the wheel of new retail", which believes that technology drives the retail industry to change. And put forward a new concept of "technical boundary line", thinking that retail enterprises can win the competition in the retail market only by carrying out technological innovation and making the technological boundary line move. Jiang Yaping and Ren Xiaoyun (2017) [12] believe that the theory starts from four dimensions of retail price, retail management level, technology and management, and utility function, and explores the motivation and development direction of retail industry reform. This theory holds that there will always be companies in the industry that will take the lead in technological innovation to gain market share and increase profits and force other companies to carry out technological innovation. Companies that have not carried out technological innovation or that are slow in technological innovation will be eliminated from the market. When the industry as a whole carries out technological innovation, companies with leading technologies in other industries will enter the market to compete for market share to obtain excess profits. At this time, the excess profit in the market gradually decreases or even disappears, inspiring enterprises to carry out the next technological innovation. Therefore, the theory further develops and enriches the retail cycle theory.

The emergence of new species such as unmanned retail in the process of new retail development benefits from the upgrade of commercial formats and changes in business models in the real economy, and at the same time, it also depends on the impact of technological changes in the virtual economy [13]. The theory of "The Wheel of New Retail" regards technological innovation as the core of retail industry reform for the first time, and points out that enterprises should develop and introduce new retail formats in line with the market environment. This theory believes that technological innovation is the competitiveness of enterprise development. Enterprises should rely on technological innovation rather than price competition to win market competition [14]. This theory supports the research of this paper and affirms the role of technological innovation in the emergence and development of new retail. This paper will use the "Wheel of New Retail" theory as the theoretical support to study the way and impact of artificial intelligence technology to empower new retail [15].

3.2 Artificial Intelligence Technology Drives the Development of New Retail

Artificial intelligence is applied to all aspects of new retail to promote its development. Specific applications include intelligent supply chain, intelligent logistics, and intelligent warehouse. Artificial intelligence covers many aspects of digital technology, such as robotics, language recognition, and image recognition. Artificial intelligence can allow consumers to experience the fun of shopping scenarios fully. Previously, some scholars have discovered that artificial intelligence, combined with advanced VR/AR technology, has enriched consumers' consumption experience and significantly improved customer satisfaction.

Table 1. Application of AI in new retail

Application Scenario	Main Technology	Case
unmanned retail store	facial recognition identification, product identification, etc.	Amazon go, Bingo Box unmanned convenience store, etc.
Smart warehousing and logistics	Smart robots, etc.	JD.com book management (only 12 people can manage hundreds of thousands of SKUs)
Intelligent Prediction and Marketing	Build Predictive Models and Algorithmic Mechanisms	Offline: the location selection of stores, etc. Online: the distribution of commodity warehouses, etc.
Intelligent customer service	Robots have powerful learning and language processing capabilities	Offline: Hema Xiansheng's robot-themed restaurant Online: JD.com's Intelligent Customer Service - JIMI
Intelligent virtual experience	VR/AR technology, etc.	Ali entered the VR industry, and previously participated in the market as well as Hammer, Facebook and Google, etc.

The retail format that new retail ultimately wants to form is to realize intelligence, and artificial intelligence is its core technology. IDC predicts that artificial intelligence will become a critical breakthrough point in the reform of the retail industry, and will become the core weapon for the future development of retail enterprises. Goldman Sachs predicts that artificial intelligence will bring new profit points to the global retail industry. By 2025, it is expected to bring in $41 billion in annual revenue. At the same time, it can help businesses save $54 billion in overhead. For example, JD.com's intelligent customer service robot JIMI saved more than 100 million yuan in labor costs in 2017. At present, the scenarios in which mature artificial intelligence is applied to the new retail field include the following categories, as shown in Table 1.

4 Core Technologies and Applications of AI Empowering Unmanned Retail

Unmanned retail is one of the new varieties of retail. Unmanned retail refers to a type of retail store or shop where there are no sales associates or employees present, and the entire shopping process is automated through technology such as self-service kiosks, vending machines, or mobile apps [16]. Customers can browse products, make purchases, and receive support through digital means, without the need for human interaction. The goal of unmanned retail is to provide a convenient and efficient shopping experience for customers, while reducing operating costs for retailers. It realizes the digitization of the entire industry chain and reshapes the relationship between "people, goods and

markets". Compared with other forms of new retail, the empowerment of unmanned retail through technological innovation is mainly reflected in two aspects. The first is to provide new channels for consumers to enrich consumption scenarios. The second is to save front-end costs for operators and expand store layout.

4.1 Unmanned Retail Demand Scenario Analysis

According to the research report by the China Industry Information Network, the distribution of demand scenarios for unmanned retail is shown in Fig. 1. It can be seen that unmanned retail is closer to the fixed passenger flow than traditional retail, and has expanded the consumption area of office areas (offices and office buildings) and community scenarios. According to a report released at the 2020 Smart Unmanned Retail Conference, the common feature of emerging scenarios of unmanned retail is that they are closer to consumers. After mobile payment was integrated into emerging consumption scenarios, customer satisfaction increased from less than 55% to more than 85%. While satisfying customers' "close-range" shopping, it also improves customer shopping satisfaction. At the same time, the audience's age has also expanded from the previous 18 to 38 years old to 12 to 72 years old. Unmanned retail has enriched people's consumption scenarios and brought a convenient shopping experience to customers.

Until now, unmanned retail mainly includes four forms: open shelves, unmanned containers, unmanned convenience stores, and unmanned supermarkets (as shown in Table 2). Among them, the open shelf project quickly withdrew from the market in 2018 due to multiple factors such as high cargo damage rate and high operating costs. Open Shelf only uses QR code scanning technology in the payment link. Due to the low technical content of other links, its logistics and operating costs are even higher than traditional convenience stores. Compared with open shelves, unmanned containers and unmanned convenience stores are more controllable for merchants, which is conducive to big data analysis to better judge market changes. Unmanned supermarkets have higher

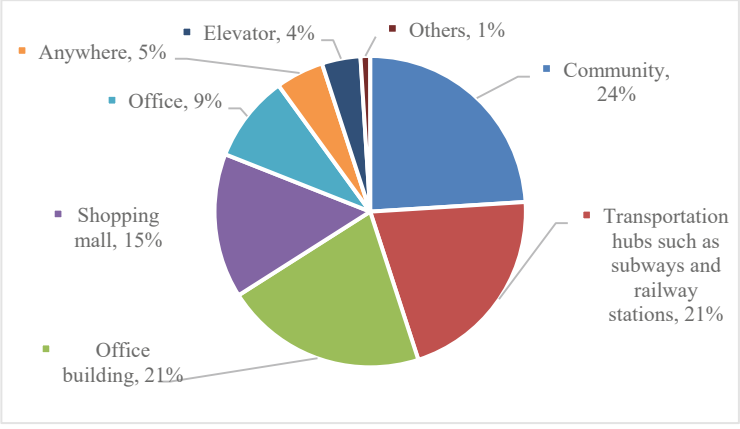

Fig. 1. Scenario analysis of unmanned retail demand

technical requirements for enterprise logistics, warehousing, supply chain, and other links, which is difficult for initial enterprises to enter.

4.2 Analysis of Core Supporting Technologies in Unmanned Retail Business

So far, unmanned retail consumption scenarios mainly include identity confirmation, purchase behavior confirmation, and payment confirmation. The links are inseparable from the support of artificial intelligence technology.

A. Identity confirmation.

There are currently two main types of identity confirmation used in unmanned retail consumption scenarios: one is the use of biometric technology based on face recognition. In foreign countries, Amazon go and Microsoft's CRM face recognition technology has been developed more maturely. In China, Ali is trying to promote the use of face recognition, using the Face + + artificial intelligence open platform.

The other type is to combine the account information in the software of the customer's mobile client (such as Alipay, WeChat, etc.) to complete the identity verification and bind it through interaction (such as scanning the QR code, etc.). Face recognition is widely used in biometrics because of its high accuracy, safety, and moderate equipment cost, and is used in security systems, station ticket checking, etc. In the development of new retail, face recognition technology also occupies a place. Face recognition consists of five steps, namely acquisition, detection, preprocessing, feature extraction and matching recognition (as shown in Table 3).

The application of face recognition technology includes two stages of registration and identification in identity confirmation. In terms of registration, Microsoft adopts a posteriori mode, that is, merchants extract the characteristics of customers entering the store through face recognition technology, create face IDs, and complete user registration. The posteriori mode is more convenient for customers as they do not need to perform facial recognition before shopping. In terms of recognition, unmanned retail can generally ensure good lighting in the face recognition area, and the camera positions are deployed at the same angle, creating powerful conditions for capturing faces for recognition.

B. Purchase behavior identification.

Table 2. Main forms of unmanned retail

Main form	Floor space/ m^2	Mode	Distance to consumers	Represent -ative firm
Open Shelf	< 10	Open	Nearest	Daily Fresh
Unmanned container	< 10	Closed	Nearer	Youbao
Unmanned convenience store	10–30	Modes are different	Further	Bingo Box
Unmanned supermarket	100–1000	Semi-open	Furthest	Amazon go

Table 3. The composition of the face recognition system

Section	Main Content	Main Algorithm
Collection	Collect the original image of the face, which can be dynamic or static according to the advanced level of the equipment	
Detection	Screen out the useful information of the collected face, such as structure, etc.	Adaboost
Preprocessing	Perform denoising, complete face size changes, etc., to facilitate feature extraction	
Feature extraction	Local	Gabor filtering
	Global	PCA, LDA algorithm
Match recognition	1. Complete the face matching with the reserved account for identification; 2. Match with the face database before the store to determine the number of times of entering the store (unmanned retail)	decision tree Classification , etc.

Purchase behavior confirmation mainly includes purchase behavior identification and purchased commodity identification. Among them, behavior recognition mainly includes image recognition technology, sensor technology, and computer vision technology; commodity identification mainly includes RFID technology, scanning code recognition technology, and computer vision technology.

In the field of behavior recognition, the combination of sensor and image recognition technology and computer vision technology are mainly used. First, the combination of sensors and image recognition technology can automatically detect customer purchase behavior. Not only can the virtual shopping cart situation of the customer be updated in time, but also help the merchant to grasp the dynamics of the goods in time. The pressure sensor can measure the weight of the item and then distinguish commodities of different weights, so it is regarded as one of the important technologies for the settlement of substitute commodities. However, there are some foreseeable problems with just using a pressure sensor.

Second, in the field of computational vision, an important technical direction is human gesture detection (or recognition), that is, to recognize human gestures and actions through pictures taken by cameras. Similar to the extraction of customer feature information by face recognition, posture detection is to identify the posture in the picture by comparing it with the trained posture model. At present, the technology is still in the research and development stage and has not been applied to offline stores.

In the field of commodity identification, commodity coding technology is currently the most widely used in the retail industry. The initial barcode and QR code usage rate is extremely high, and the rest also include RFID, NFC, etc.

Scanning identification methods based on barcodes and QR codes are widely used in the initial development of unmanned retail because of its low cost and unified market

standards. However, at present, the manual operation of barcodes is relatively cumbersome, and the two-dimensional code has a certain waiting time during settlement, and its status is gradually replaced by RFID technology. In traditional retail, these two identification methods are still mainly used for commodity identification.

Artificial intelligence technology helps merchants efficiently complete the product identification process and ensure that customers accurately grasp the product details. With the upgrade of consumers' consumption experience, under the new retail format, consumers can learn more product information through product identification when selecting products, and product identification will become a bridge between consumers and manufacturers. It has changed the face-to-face communication method of traditional retail, making the communication process more efficient.

C. Payment confirmation.

Electronic payment technology is the last and most important link in the unmanned retail consumption scenario. Amazon's "Just Walk Out Technology", it can be seen that the emphasis is also on the simplification of the payment process.

At present, electronic payment is showing diversified development, which is mainly reflected in six forms, namely online payment, electronic money, electronic check, online banking, mobile payment and third-party payment. Unmanned retail is currently the most important part of payment confirmation through third-party payment.

Currently the mobile payment market has formed a duopoly between Alipay and Tencent. Alipay has launched a cashless parking lot business to pave the way for the strategic layout of unmanned retail. In addition, Tencent and Ali have also started layout and competition in the overseas payment market.

In the unmanned retail scenario, the payment link still plays the role of connecting commodities, customers and retailers. From the perspective of demand, mobile payment technology enriches the customer's payment experience, and the payment process is more interesting, proactive and participatory. For retailers, after using artificial intelligence technology, customer payment data can be widely collected and analyzed, so as to accurately analyze customers' consumption preferences and provide better services. In the new retail scenario, the payment link builds a close connection between customers, supply chain companies and retailers. After mastering consumer preferences, manufacturers and retailers can provide unique supply and marketing solutions for individual consumers.

5 Case Study - Taking NBY Company as an Example

5.1 Analysis of Unmanned Retail Business for NBY Company

NBY company has provided printing solutions for cashier management and other related businesses in the retail industry for enterprises such as China Resources Vanguard Supermarket. In 2017, after formulating a new retail business plan, the company demonstrated its unmanned convenience store solutions at the first UREXPO China Unmanned Store Conference and Exhibition.

NBY's unmanned retail stores are equipped with self-service kiosks, vending machines, and mobile apps, allowing customers to browse and purchase products without the need for human interaction. The company has carefully selected products that are

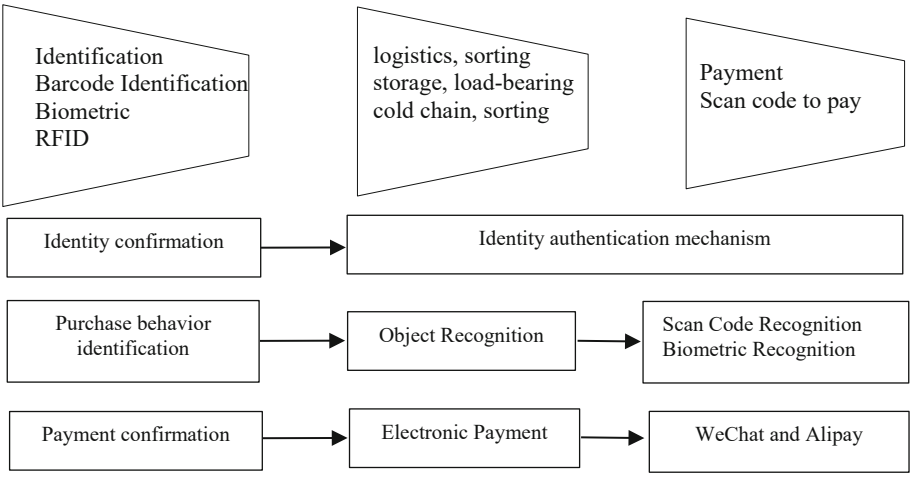

Fig. 2. NBY's business-level technical support

well-suited for unmanned retail, such as snacks, drinks, and personal care items, and has designed the vending machines and kiosks to be user-friendly and aesthetically pleasing. One key advantage of NBY's unmanned retail business is that it allows the company to reduce operating costs by eliminating the need for sales associates. Additionally, the automated systems used by the company are able to process transactions faster and more accurately than human sales associates, resulting in a more efficient shopping experience for customers. Another advantage of NBY's unmanned retail model is that it provides the company with access to new markets and customers who may not have been accessible through traditional retail channels. For example, NBY's vending machines and kiosks can be placed in locations such as airports, office buildings, and residential buildings, allowing the company to reach a wider customer base.

At the business level, the company's high-tech in the fields of printing and identification, logistics and sorting, and payment has laid the foundation for the expansion of new retail businesses (as shown in Fig. 2). The final settlement of goods supports WeChat, Alipay, biometric identification and scanning code identification methods (QR code, RFID code). In the new retail field, the company focuses on developping unmanned container business. It adopts the identity authentication mechanism for identity authentication, which has low cost and high reliability. In terms of shopping behavior confirmation, the main technologies currently used are RFID technology and biometric identification technology. In the field of payment, electronic payment technology is adopted to realize cashless operation.

5.2 Market Effect and Economic Effect of Unmanned Retail Business

NBY has entered the "secondary entrepreneurship" since 2017, focusing on the development of new retail business. According to the company's announcement, in 2019, the company's new retail business achieved operating income of about 1.986 billion yuan, accounting for about 75.4% of the revenue. According to the company's 2019 financial

annual report, before the development of Xin Beiyang's new retail business, the operating income of emerging business areas was about 1.251 billion yuan, accounting for 67.3% of revenue, an increase of 8.1 percentage points.

In addition, from 2017 to 2019, its stock price performance has always outperformed the stock price performance of the broader market (CSI 300 index), but slightly lower than the rise and fall of the computer industry index (930651.CSI). After the company achieved mass production of unmanned containers in its new retail business in 2019, its stock rose and fell higher than the broader market and industry trends. It can be seen that the development of new retail business has had a positive impact on the company. To sum up, NBY has achieved preliminary results by using technology to empower new retail.

6 Conclusion and Outlook

The "New Retail Wheel" theory proposed by Japanese scholar Masao Nakanishi serves as the foundation of this study. The integration of technologies like AI sets new retail apart from traditional retail. By leveraging technology in the procurement, warehousing, distribution, and sales processes of the traditional retail industry, it drives the growth of new retail and enhances the operational efficiency of businesses.

Unmanned retail is a digital retail format that streamlines the entire industry chain and enhances store efficiency. This retail model expands consumer channels and offers diverse purchasing experiences. The key components of the purchasing experience include customer identity verification, purchase behavior confirmation, and payment confirmation. Identity verification mainly uses biometric techniques, such as face recognition, and Internet-based identification systems. Purchase behavior confirmation employs pressure sensors, image recognition, and RFID technology. Payment confirmation mostly relies on electronic payment systems, with third-party payment being the most popular in the retail sector. In the future, the dominance of Alipay and Tencent Financial is expected to continue. Artificial intelligence technology is the core of unmanned retail, meeting the needs of consumers, businesses, and society. However, finding the right balance between technology and customer needs takes time to develop. A successful retail transformation can only be achieved when demand and technology align. Companies must prioritize the development of AI, stay true to the essence of retail, and explore new retail formats to succeed in the new retail landscape.

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