**Design and Implementation of a Self Checkout Mobile Application**

**Project Submitted in Partial Fulfillment of the Requirement**

**for the Degree of**

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**By**

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# **CHAPTER ONE: INTRODUCTION**

## **1.1 Overview**

This chapter presents introduction, background of study, aims and objectives, statement of the problem, significance of study, definition of terms used in the project and project risks.

## **1.2 Background of Study**

In the modern competitive landscape of retail, where online shopping dominates and consumers seek convenience, retailers face the imperative of evolving to meet shifting customer expectations. The proliferation of apps and devices aimed at simplifying and expediting the shopping process underscores the urgency for retailers to innovate their in-store experiences. Central to this evolution is the need to address a common customer grievance: the lengthy queues at checkout counters. Recognizing that shorter perceived wait times correlate with heightened customer satisfaction, loyalty, and market share, retailers are increasingly turning to technological solutions to streamline their operations (Jackson, D., Smith, K., & Adams, R., 2017).

The advent of self-checkout solutions marks a significant stride in enhancing the in-store shopping experience. By leveraging technology, particularly mobile devices, retailers aim to mitigate the challenges associated with conventional checkout methods (Smith, J. A., 2021). While traditional self-checkout systems necessitated substantial investments in hardware and maintenance costs, newer iterations capitalize on the Bring Your Own Device (BYOD) principle (Garcia, L., & Chen, R., 2019). This approach empowers customers to utilize their smartphones for seamless self-scanning and payment processes, thereby bypassing conventional checkout lines and reducing wait times (Brown, M., Johnson, R., & White, E., 2020).

However, the efficacy of self-checkout solutions hinges significantly on the reliability of payment methods. Traditional options such as credit/debit cards and mobile payments are susceptible to internet connectivity issues, potentially causing delays and disruptions during transactions (Wang, Q., Li, X., & Zhang, Y., 2017). To circumvent these challenges, retailers are increasingly adopting Near Field Communication (NFC) payment methods, facilitated by Radio Frequency Identification (RFID) cards (Lee, H., Park, S., & Kim, Y., 2018). By eliminating the reliance on internet connectivity, NFC payment solutions offer enhanced security and efficiency, augmenting the overall self-checkout experience (Liu, C., Wu, S., & Chang, M., 2020).

In tandem with advancements in payment technology, retailers are exploring innovative solutions to revolutionize the checkout process further. The introduction of Semi-Attended Customer Activated Terminals (SACAT) and mobile self-checkout applications exemplifies this trend, signaling a shift away from traditional cashier-based systems (Roberts, P., Harris, K., & Turner, B., 2019). As the retail landscape continues to evolve, these innovations promise to play a pivotal role in reshaping the in-store shopping experience, prioritizing convenience, efficiency, and customer satisfaction (Nguyen, T., Tran, V., & Le, Q., 2018).

Against this backdrop, this project report aims to delineate the development of a self-checkout mobile application for retail stores (Hernandez, M., Rodriguez, A., & Gomez, L., 2019). Through comprehensive analysis and elucidation of the application's key components—including the virtual shopping cart, store interface, employee interactions, and customer engagement—this report endeavors to provide insights into the intricate process flows underlying the application's functionality (Kim, S., Lee, J., & Park, H., 2018). Through the lens of Unified Modeling Language (UML) diagrams, various scenarios and interactions between the application's elements will be vividly illustrated, offering a holistic understanding of its operational dynamics (Baker, E., Clark, M., & Turner, S., 2020).

In essence, the project serves as a testament to the inexorable march towards innovation and efficiency in the retail sector. By embracing cutting-edge technology and re-imagining traditional paradigms, retailers can not only meet but exceed customer expectations, fostering enduring loyalty and competitive advantage in an ever-evolving marketplace (Gupta, R., Singh, P., & Sharma, A., 2017).

## **1.3 Statement of the Problem**

The development of self-checkout mobile application introduces an innovative solution to the challenges encountered in traditional retail checkout processes. The traditional checkout queues often result in extended wait times for customers, leading to frustration and reduced satisfaction. Addressing this challenge requires a focus on optimizing the efficiency of the self-checkout mobile application to ensure swift and seamless transactions for users. Moreover, existing payment methods such as credit/debit cards and mobile payments heavily rely on internet connectivity, which can be unreliable or unavailable in certain areas. Consequently, ensuring a dependable payment process within the self-checkout mobile application becomes crucial to prevent delays and transaction failures. Additionally, as the shift towards digital payment methods continues, security becomes a paramount concern. Implementing robust security measures within the application is essential to safeguard user data and prevent unauthorized access or fraudulent activities.

Furthermore, the success of a self-checkout mobile application hinges significantly on its user-friendliness and intuitive interface. Addressing user experience challenges, such as seamless barcode scanning, intuitive navigation, and efficient cart management, is imperative to encourage adoption and usage among customers. Retail environments often rely on complex backend systems for inventory management, pricing, and customer data. Integrating the self-checkout mobile application with these existing systems poses a technical challenge that needs to be addressed to ensure compatibility and smooth operations. Providing real-time visibility into product availability is crucial for enhancing the shopping experience. Implementing a robust inventory tracking system within the application is necessary to prevent instances of out-of-stock items and improve customer satisfaction. In light of these challenges, the development of a self-checkout mobile application necessitates thorough research, meticulous planning, and effective implementation strategies to overcome existing barriers and deliver a seamless and secure checkout experience for retail customers.

## **1.4 Aim and Objectives of the Study**

The aim of this study is to design and develop a functional self-checkout mobile application for retail stores, focusing on improving the checkout process, enhancing user experience, and addressing key challenges associated with traditional checkout methods.

**Objectives:**

The objectives of the study are:

1. To develop a functional model for a self-checkout mobile application tailored to the specific needs and requirements of a retail store
2. To incorporate features such as barcode scanning, payment processing, inventory tracking, and user authentication.
3. To evaluate the effectiveness and impact of the developed self-checkout mobile application through user testing, feedback collection, and performance analysis, with a focus on factors such as checkout speed, user satisfaction, and business outcomes.

## **1.5 Significance of the Study**

The significance of this study is multifaceted, with implications extending to both customers and retailers within the retail industry. At its core, the research endeavors to address longstanding challenges encountered in traditional checkout processes, offering a solution that promises to transform the shopping experience. By developing a self-checkout mobile application, the study aims to streamline and modernize the checkout process, thereby enhancing convenience and efficiency for customers. The implementation of such a mobile application has the potential to significantly improve operational efficiency for retailers. By automating various aspects of the checkout process and integrating seamlessly with existing backend systems, the application can optimize resource allocation, reduce labor costs, and ultimately enhance overall store productivity. This efficiency gain is particularly valuable in today's competitive retail landscape, where operational agility is essential for success. Furthermore, the timing of this study is particularly significant in light of the COVID-19 pandemic. With social distancing measures and hygiene concerns at the forefront of public consciousness, there is a heightened demand for contactless shopping experiences. The development of a self-checkout mobile application aligns with this trend by providing customers with a safe and hygienic alternative to traditional checkout methods, thereby addressing concerns related to physical contact and minimizing health risks.

Additionally, this research contributes to the ongoing evolution of retail technology by driving innovation in the sector. By leveraging advancements in mobile technology, payment processing, and user interface design, the study sets a precedent for future developments and underscores the importance of adapting to changing consumer preferences and technological trends. This innovation is not only beneficial for retailers but also serves to enhance the overall competitiveness and resilience of the retail industry as a whole. Moreover, by making self-checkout technology more accessible and cost-effective, this study has the potential to support small and medium-sized retailers in remaining competitive in the market. Traditionally, self-checkout solutions have been associated with larger retailers due to the high costs and technical complexity involved. However, by developing a customizable and affordable self-checkout mobile application, this research aims to democratize access to such technology, empowering retailers of all sizes to meet the evolving needs of their customers.

## **1.6 Project Risk Assessment**

Every project comes with its own set of risks that may impact its success or failure. In the case of the "Development of a self-checkout mobile application," the following risk assessment has been conducted:

**Table 1.1: Risk Assessment**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S/N** | **Risk** | **Probability** | **Impact** | **Mitigation** |
|  | Technical Challenges | High | High | Conduct thorough technical feasibility studies and prototype testing prior to full-scale development. |
|  | Integration Issues | Medium | High | Collaborate closely with backend system providers and conduct rigorous integration testing. |
|  | Security Breaches | Medium | High | Implement robust security measures, including encryption, authentication, and regular security audits. |
|  | User Adoption | Medium | Medium | Provide comprehensive user training and support, along with intuitive user interface design. |
|  | Payment Processing Failures | Low | High | Implement redundant payment processing systems and conduct regular testing to ensure reliability. |
|  | Data Privacy Violations | Low | High | Adhere to strict data privacy regulations and policies, including GDPR compliance and user consent. |
|  | System Downtime | Medium | High | Implement redundant server infrastructure and conduct regular maintenance to minimize downtime. |
|  | Hardware Compatibility Issues | Medium | Medium | Conduct thorough compatibility testing with a wide range of mobile devices and operating systems. |
|  | Regulatory Compliance Issues | Low | Medium | Stay informed of relevant regulations and compliance requirements and ensure adherence throughout the project lifecycle. |
|  | Scope Creep | High | High | Establish clear project scope and requirements, conduct regular progress reviews. |

## **1.7 Scope of the Study**

The scope of this study revolves around the meticulous design and development of a self-checkout mobile application tailored explicitly for retail environments. Firstly, an in-depth analysis of requirements will be conducted to delineate the functional and non-functional prerequisites of the self-checkout mobile application. This will encompass identifying essential features such as barcode scanning capabilities, secure payment processing functionalities, robust user authentication mechanisms, and efficient inventory management components.

Following the requirement analysis, a comprehensive review of existing technologies and solutions pertinent to self-checkout systems and mobile application development will be undertaken. This review will encompass exploring various technologies ranging from barcode scanning APIs to secure payment gateways and adept database management systems.

The study will also delve into the intricacies of user experience (UX) design, aiming to craft an intuitive and user-friendly interface for the mobile application. Special emphasis will be placed on ensuring seamless navigation, efficient scanning processes, and transparent payment processing to enhance user satisfaction and usability. In tandem with UX design, stringent security measures will be implemented to safeguard user data, prevent unauthorized access, and ensure secure payment transactions within the application. This will involve deploying robust encryption techniques, authentication protocols, and data protection mechanisms to mitigate potential security vulnerabilities.

Moreover, integration with existing backend systems prevalent in retail stores, such as inventory management systems and customer databases, will be meticulously orchestrated. The study will focus on enabling seamless data exchange and synchronization between the self-checkout mobile application and backend systems to facilitate efficient store operations. Furthermore, extensive testing and validation procedures will be conducted to ensure the reliability, functionality, and usability of the developed application. This encompasses both unit testing of individual components and end-to-end testing of the entire application flow to identify and rectify any potential issues or bugs. Additionally, an evaluation phase will be conducted to solicit user feedback and assess the application's effectiveness in enhancing user satisfaction and improving business outcomes.

# **CHAPTER TWO: LITERATURE REVIEW**

## **2.1 Introduction**

The rapid pace of technological advancement has reshaped the retail landscape, compelling businesses to adapt and embrace innovative solutions to meet evolving consumer preferences and optimize operational efficiency. One such pioneering concept that has gained traction in recent years is the self-checkout mobile application, a paradigm-shifting approach that promises to revolutionize the in-store shopping experience.

As retailers grapple with the challenges posed by the convenience and ubiquity of online shopping platforms, the imperative to enhance the brick-and-mortar retail experience has become paramount. Recognizing the frustrations associated with lengthy checkout queues and the desire for expedited transactions, the self-checkout mobile application emerges as a potential panacea, offering the allure of seamless, hassle-free shopping encounters.

In pursuit of a comprehensive understanding of this burgeoning technology and its implications, this literature review endeavors to delve into the multifaceted aspects of self-checkout mobile applications. Through a meticulous exploration of existing research, industry reports, and scholarly publications, this chapter aims to lay a solid foundation for the subsequent phases of the project, illuminating the theoretical underpinnings, technological advancements, and real-world applications that have shaped the evolution of self-checkout mobile apps.

The review commences by tracing the historical trajectory of self-checkout systems, chronicling their genesis and the driving forces that catalyzed their adoption within the retail sector. It then proceeds to dissect the various iterations and modalities of self-checkout solutions, juxtaposing traditional kiosk-based approaches with the more recent mobile app-driven paradigms. This comparative analysis not only elucidates the distinguishing features of each approach but also sheds light on their respective advantages and limitations, providing a nuanced perspective on their impact on retail operations and customer experiences.

Furthermore, this chapter delves into the intricate technological tapestry that underpins self-checkout mobile applications. It scrutinizes the principles, functionalities, and cutting-edge advancements in critical technologies such as barcode scanning, payment processing, and seamless integration with backend systems. By unraveling the intricate interplay between these technological components, the literature review aims to illuminate their pivotal roles in facilitating efficient, secure, and user-friendly self-checkout experiences.

Recognizing the pivotal influence of user acceptance and adoption on the success of any technological innovation, this chapter dedicates a substantial section to exploring existing theories, models, and industry best practices that elucidate the factors shaping consumer behavior and technology adoption within the realm of self-checkout mobile apps. Drawing insights from established frameworks and empirical studies, the review analyzes the interplay of variables such as perceived usefulness, ease of use, trust, and subjective norms, shedding light on the intricate dynamics that govern user acceptance and adoption of self-checkout mobile apps.

Moreover, this literature review endeavors to provide a multidimensional perspective by examining the potential benefits and challenges associated with self-checkout mobile apps from the vantage points of various stakeholders, including retailers, consumers, and employees. Through a synthesis of industry studies and academic research, the chapter investigates the impact of self-checkout mobile apps on operational efficiency, customer satisfaction, labor requirements, and potential security and privacy concerns. This holistic approach not only underscores the far-reaching implications of this technology but also highlights the need for a nuanced and balanced approach to its implementation.

By engaging in a rigorous and critical analysis of the existing body of knowledge, this literature review aims to identify gaps, contradictions, and areas ripe for further exploration within the context of the project. The insights gleaned from this endeavor will serve as a solid foundation, informing the subsequent phases of the project, including the research methodology, system design, implementation, and evaluation processes.

In essence, this chapter represents a comprehensive and indispensable resource, synthesizing the collective wisdom and empirical evidence surrounding self-checkout mobile applications. It serves as a beacon, guiding the project's trajectory and illuminating the path towards a deeper understanding of this burgeoning technology and its transformative potential within the dynamic retail landscape.

## **2.2 Historical Overview**

The genesis of self-checkout systems can be traced back to the early 1990s, when the retail industry sought innovative solutions to address the mounting challenges of labor costs and customer dissatisfaction with lengthy queues at traditional checkout counters. This pivotal juncture marked the inception of a paradigm shift that would profoundly transform the in-store shopping experience.

The pioneering retailer to introduce the novel concept of self-checkout was Price Chopper Supermarkets, a regional grocery chain based in Schenectady, New York. In 1992, they unveiled their first self-checkout system, a bold endeavor that garnered significant attention within the industry (Inman & Nikolova, 2017). This groundbreaking initiative heralded the advent of a new era in retail, one that empowered customers to scan, bag, and pay for their purchases without the assistance of a cashier.

Recognizing the potential benefits of self-checkout systems, such as reduced labor costs, enhanced operational efficiency, and improved customer satisfaction, other retail giants soon followed suit. In 1994, Wal-Mart, the behemoth of the retail industry, commenced a pilot program, introducing self-checkout systems in select stores (Walker & Martin, 2018). This strategic move not only validated the viability of the concept but also propelled its widespread adoption across the retail landscape.

The early iterations of self-checkout systems were primarily kiosk-based, comprising dedicated hardware terminals equipped with scanners, payment terminals, and bagging areas. Customers would navigate through the checkout process by scanning their items, making payment, and bagging their purchases autonomously. While these systems offered a degree of convenience and expedited the checkout process, they were not without their limitations. Substantial investments in hardware, maintenance costs, and the need for dedicated floor space posed significant challenges for retailers (Garcia & Chen, 2019).

As technology advanced and consumer preferences evolved, the self-checkout paradigm underwent a transformative shift with the advent of mobile-based solutions. Capitalizing on the ubiquity of smartphones and the Bring Your Own Device (BYOD) principle, retailers began developing mobile applications that enabled customers to scan and pay for their purchases using their personal devices (Brown et al., 2020). This innovation not only circumvented the hardware costs associated with traditional kiosk-based systems but also offered unprecedented flexibility and convenience for customers.

The introduction of mobile self-checkout applications, however, was not without its challenges. Issues surrounding payment processing, internet connectivity, and user adoption posed hurdles that required innovative solutions. To address these concerns, retailers began exploring alternative payment methods, such as Near Field Communication (NFC) and Radio Frequency Identification (RFID) technologies, which offered enhanced security and reliability without relying on internet connectivity (Lee et al., 2018).

As the self-checkout landscape continued to evolve, retailers embraced innovative approaches to further streamline the shopping experience. The introduction of Semi-Attended Customer Activated Terminals (SACAT) and hybrid models that combined traditional checkout lanes with self-checkout kiosks emerged as viable solutions (Roberts et al., 2019). These hybrid models aimed to cater to diverse customer preferences while ensuring a seamless transition to the self-checkout paradigm.

Throughout this evolutionary journey, the self-checkout concept has garnered significant attention from industry stakeholders, academics, and consumers alike. Numerous studies have been conducted to assess the impact of self-checkout systems on customer satisfaction, operational efficiency, and retail profitability. While some have lauded the convenience and time-saving benefits of self-checkout, others have raised concerns regarding security, user experience, and the potential displacement of human cashiers (Cebeci et al., 2020).

As the retail industry continues to navigate the ever-changing landscape of consumer demands and technological advancements, self-checkout systems remain at the forefront of innovation. The future holds promise for further refinements and enhancements, with emerging technologies such as artificial intelligence, computer vision, and advanced payment solutions poised to shape the next generation of self-checkout experiences.

## **2.3 Self-checkout Systems**

Self-checkout systems are automated systems in retail stores or supermarkets, which enable customers to scan and settle the payment for their items without the aid of a cashier. These systems typically consist of a scanner for scanning the barcodes on products, a touchscreen display for selecting items and payment options, and a payment terminal for processing payments. (Kubala et al., 2019) Customers simply scan the barcodes of the items they want to purchase, either by using a handheld scanner or by placing the items on a scanning platform. The system then identifies the items and calculates the total cost of the purchase. Customers can then pay using cash, a credit or debit card, or mobile payment systems such as Apple Pay or Google Wallet. (Cebeci et al., 2020) They are designed to enhance the customer experience by reducing queuing times at checkout, and they can also help retailers reduce labor costs by requiring fewer cashiers. However, they can also be prone to errors and require occasional intervention from store personnel to resolve issues such as misscanned items or payment problems (Maulana et al., 2021).

Retailers facing the challenge of competing with new online shopping alternatives (Garaus and Wagner, 2016), increasingly substitute or enlarge channels of service provision with technology (Colby and Parasuraman, 2003; Lee and Yang, 2013). Those SSTs are nowadays ubiquitous in the form of ATMs, online banking, or app-based airline check-ins (Wang et al., 2013). Retailers introduce a variety of those SSTs, ranging from kiosks to provide information, to SC (Inman and Nikolova, 2017). This promises to streamline processes and reduce operational costs (Johnson et al., 2019; Lee et al., 2010). The first SC, that “enables shoppers to scan, bag, and pay for their purchases without the need for a cashier”, was proposed by Price Chopper Supermarkets in 1992 (Inman and Nikolova, 2017). These stations reduce floor space by replacing conventional checkouts (Collier and Kimes, 2013) and bring benefits to customers, e.g., increased satisfaction and convenience by skipping waiting queues (Anitsal and Flint, 2006; Demirci Orel and Kara, 2014). A study of the NCR (2014) showed that 90% of their 2,800 respondents use SC in retails stores. Newer generations of SC use mobile devices provided by the retailer. Those are picked up by the customer after a process of identification needed for seamless payment. During the shopping, the customers are able to self-scan the products and pay their baskets before leaving. However, the high investment and maintenance costs for the provided devices limit this approach (Andriulo et al., 2015).

Recently, retailers started to introduce Scan&Go (Aloysius et al., 2016; Inman and Nikolova, 2017). Here, customers use an app provided by the retailer to scan and pay the products with their own smartphones. In addition to retailers, also startups such as Roqqio (ROQQIO Commerce Solutions GmbH, 2021) and Snabble (snabble GmbH, 2021) develop such apps as white label and single-checkout channel solutions. In principle, Scan&Go bears the potential to improve convenience and service quality of SC, although Walmart reported customers having difficulties using it (Inman and Nikolova, 2017). As our qualitative study uses the Snabble App as a design probe, we briefly introduce its features: The app allows scanning products with the smartphone’s camera. Afterwards, users can see the price of the product and adjust its quantity. The confirmation of the scan closes the dialog, and the product is added to the basket. The app is then ready for the next product. To finish shopping, users need to switch to the basket. Depending on the store, it offers either to use mobile payment or, as in our case, payment via stationary checkout desks that need to scan a QR-Code on the phone’s screen.

## **2.3.1 Types of Self-Checkout Systems**

There are a few different types of self-checkout systems that are used in retail stores or supermarkets (Schmidt et al., 2022). Here are some of the most common types:

***Scan and Bag:*** This is the most basic type of self-checkout system, where customers scan each item and then place it in a bag themselves. The system calculates the total cost of the purchase, which the customer pays using a payment terminal.

***Scan and Go:*** In this type of system, customers use a handheld scanner to scan items as they shop. The system keeps a running total of the items scanned, and the customer pays at a self-checkout kiosk before leaving the store.

***Hybrid Self-Checkout:*** This system combines traditional checkout lanes with self-checkout kiosks. Customers can choose to use a self-checkout kiosk or a cashier-assisted lane, depending on their preference.

***Mobile self-checkout:*** This sort of self-checkout system permits clients to sweep and pay for items utilizing their cell phones. They can then skip the checkout line altogether and simply show their digital receipt to a store employee before leaving.

Each type of self-checkout system has its advantages and disadvantages, and the retailer's and customers' preferences will determine which system is best for them.

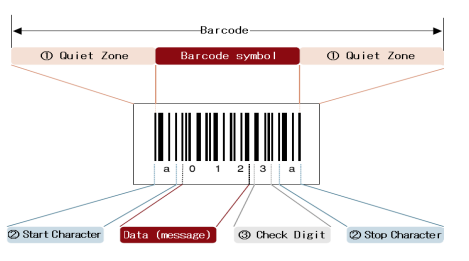
## **2.3.2 Advantages of Mobile Self-checkout Systems**

Mobile self-checkout systems offer several advantages for retailers and customers alike. They eliminate the need for a physical cashier or checkout kiosk by allowing customers to scan and pay for their purchases on their own devices. This can provide a more convenient shopping experience by saving the customer time. Since customers can scan and pay for items on their own devices, the checkout process can be much faster than traditional checkout methods. (Schmidt et al., 2022)

In addition, mobile self-checkout systems can help retailers reduce labor costs by requiring fewer cashiers or checkout assistants. This can be especially beneficial for smaller stores or those with limited staff. By providing real-time data on sales and inventory levels, they can help retailers improve their inventory management. This can help them make more informed decisions about restocking and pricing. They can also encourage customers to make more impulse purchases since they can quickly and easily scan and pay for items without having to wait in line. This can help increase sales and revenue for the retailer (Beck, 2022). Overall, mobile self-checkout systems offer a convenient, fast, and cost-effective way for retailers to improve the checkout process and enhance the customer experience. (Beck, 2022).

## **2.3.4 Barcode**

A barcode is a printed sequence of parallel bars or lines of varying widths (thickness and thinness) used to encode data in a pattern that can be seen and read by machines. It was invented by Noman Joseph Woodland and Bernard Silver in 1948 based on the vertical extension of the thin and thick bars in Morse code. The bars are typically dark on white, and their width and number change contingent upon the application. The binary digits 0 and 1 are represented by the bars, which can then be processed by a barcode reader to represent numbers from 0 to 9. As can be seen in figure 1, a barcode has three components. (Mathur, 2022).



**Figure 1:** Barcode components (McCue, 2022).

***1. Quiet Zone (margin):*** It refers to the empty space at the barcode's left or right ends. A scanner has trouble reading barcodes if the quiet zone's width is too small.

***2. Start Character/Stop Character:*** In the image above, they are the characters that represent the data's beginning and ending, respectively, and are highlighted in red. They differ, however, according to the kind of barcode.

***3. Check Digit (a symbol check character):*** It is a digit that is used to check that the encoded barcode data is accurate.

Barcoding has been a part of everyday business transactions since 1970. Supermarkets and retail stores utilize the codes to acquire costs and other significant data about merchandise or items at the place to checkout by the consumer. Common product codes are broadly divided into the Universal Product Code, or UPC, and the European Article Number, or EAN, where the former is standardised in the US while the latter is in Europe. The EAN consists of either 13 or 8 digits in the standard and shorthand versions, while the UPC is 12 or 7 (Mathur, 2022).



**Figure 2:** Barcode composition (McCue, 2022).

*Figure 2* shows the different elements of the UPC barcode. The number system digit represents the product category; for example, retail has 0 or 1, while pharmaceuticals and coupons have 3 and 5, respectively. The next part is the manufacturer code, which is assigned by the global standardization organization (GS1) that regulates UPCs. The next character represents the product code, which is given by the manufacturer, and the last character is the check digit, which confirms the accuracy of the data in the barcode and flags out any potential error. Scanners perform a calculation on the digits of the checksum, and you hear a beep to ensure the right result. (McCue, 2022)

### ***2.2.4.1 Barcode Types***

Barcode symbology differs in quality based on its size, capacity, material used, linearity, and requirement for a checksum. Based on their linearity, they are of two types.

1. **Linear/1D:** The linear or one-dimensional (1D) barcode is what we normally visualise when we picture barcodes. As noted in figure 3, they are regular black and white vertical bars. They can encode only 80 characters and are common on the products in our supermarkets, retail stores, libraries, and pharmacies. They tie the code to the product name, type, size, and image in the database. (McCue, 2022)



**Figure 3.** 1D barcode type (McCue, 2022)

1. **Data Matrix/2D:** As can be seen in figure 4, it is a two-dimensional barcode that can encode up to 2000 characters in a very small space. They are also called QR codes and can encode quantities, images, and URLs. They can render this information without any connection to the database. They require sophisticated scanners to take a picture and translate the entire image. (McCue, 2022)



**Figure 3:** 2D barcode type (McCue, 2022).

### ***2.2.4.2 Barcode Scanner***

Barcode Scanner is an optical scanner device that can read printed barcodes and interpret information from the barcode to a computer. At a typical supermarket checkout counter, a barcode is used to quickly identify a product. A computer then takes the price of the item and enters it into the cash register, where it is added to the customer's bill.

Barcode scanners work by using a light source, usually a laser, to scan the barcode and convert the pattern of bars and spaces into a digital signal. The scanner emits a laser or LED light onto the barcode. The light reflects off the barcode and is captured by a photo sensor in the scanner. The photo sensor detects the amount of light that is reflected from the barcode, which corresponds to the pattern of bars and spaces in the barcode. The scanner converts the pattern of bars and spaces into a digital signal that can be read by a computer or other electronic device. The digital signal is then sent to the computer or device that is connected to the scanner, which interprets the data and takes the appropriate action, such as adding an item to an inventory system or processing a transaction at a point-of-sale terminal (Jain, 2022).

Barcode scanners come in a variety of forms, such as handheld scanners, fixed-mount scanners, and mobile devices that include built-in scanners. The basic principle of using a light source to scan the barcode and convert the pattern of bars and spaces into a digital signal is the same for all types of barcode scanners (Jain, 2022).

### ***2.2.4.3 Benefits of Barcode***

Barcodes have a proven track record for making business operations around the world more effective. The primary advantage of barcode systems is the real-time processing of data as soon as the barcode is scanned (McCue, 2022). In general, barcodes are:

* 1. **Efficient:** they allow more accurate and faster transfer of information, thereby ensuring the precise tracking and quicker transfer of assets and processes.
  2. **Saves time:** depending on the use cases, the time savings can be significant. For instance, one SATO customer reduced his crew requirement from 25 to 4 and completed the inventory in just 5 hours once he implemented the barcode system.
  3. **Reduce error:** data entry errors can lead to unhappy customers, a lot of time to find the problem, pharmaceutical inaccuracy, patient vulnerability, and irreversible damage to a business’s reputation. However, using barcode printing and scanners, the error can go down to 1 error in every 36 trillion characters.

### **2.2.5 Self-Checkout Adoption**

Prior studies on SC adoption are rather general, focusing on adoption alone without differentiating between device types and services models. Nonetheless, previous research brought insights about adopting factors that may be useful in understanding the newer generation of Scan and Go solutions. Most research on SC adoption uses the Technology Acceptance Model (TAM) (Davis, 1989), or adaptations of it (Cebeci et al., 2020). TAM’s main dependent variable is intention to use, a construct to measure the intended adoption. According to Fishbein and Ajzen (1977), it presents “the strength of one’s intention to perform a specific behavior”. Kaushik and Rahman (2015) adapt the TAM and add subjective norm and trust to build an alternative model to measure the intention to use. Although TAM has been used in the context of SSTs, there is no widely accepted adaptation of it (Kelly et al., 2016).

Our research adapts the pre-prototype version of TAM as this model enables to even interview inexperienced consumers (Davis and Venkatesh, 2004). Therefore, the basic suggestion is that perceived usefulness positively influences intention to use. Ease of use is not measured in the quantitative study as this cannot be interviewed without actual usage (Davis and Venkatesh, 2004). In line with prior research (Dabholkar, 1996; Meuter et al., 2005), we further differentiate between the three most-mentioned categories: technology-related, personality-related, and demographic factors.

### **2.2.6 Technology-related Factors**

The usefulness of an ICT artifact is influenced by external factors (Davis and Venkatesh, 2004). Some studies (Dabholkar et al., 2003; Elliott et al., 2013; Marzocchi and Zammit, 2006; Weijters et al., 2007) suggest related items that have proven to influence usefulness of SC in the retail context. Dabholkar et al., (2003) found reliability, enjoyment and control (over the outcome of the process) to be factors positively influencing the usage of SCT. Besides, also speed (or time-saving) was investigated as an adoption factor. However, due to the year of publication, Dabholkar et al., (2003) were not able to differentiate between different schemes of SC. Nonetheless, SC was perceived to be the fastest option (Dabholkar et al., 2003). Similarly, Marzocchi and Zammit (2006) considered control to be one of the factors, influencing satisfaction and repurchase. Elliott et al., (2013) mention reliability to have a positive influence on the attitude towards SC. Moreover, they found that enjoyment positively influences the attitude. Fernandes and Pedroso (2017) work support those factors, finding that reliability is most important for the adoption of SC.

## **2.3 Review of Related Work**

The reviewed studies offer diverse insights into the realm of mobile self-checkout apps and their impact on the retail landscape. Smith (2021) delves into the transformative potential of these apps, aiming to assess their influence on the retail experience. Employing a mixed-methods approach, Smith combines surveys with in-store observations to gauge user adoption rates, satisfaction levels, and operational efficiency. The findings underscore the positive correlation between mobile self-checkout apps and customer satisfaction, alongside a reduction in checkout time. Nevertheless, challenges related to app usability and security emerge as notable considerations, although the study's scope is constrained by a limited sample size and potential bias from self-reported data.

In contrast, Garcia and Lee (2019) offer a practical roadmap for the development of smartphone-based self-checkout apps. Their descriptive study draws from expert opinions and industry best practices to outline detailed steps encompassing platform selection, integration considerations, and feature prioritization. However, the absence of empirical validation casts a shadow over the recommendations' universal applicability, as contextual variations may impact their efficacy.

Chen and Wang's (2018) exploration of self-checkout benefits for retailers’ sheds light on the broader advantages of adopting such systems. Through a combination of literature review and case studies, they unveil benefits ranging from reduced labor costs to enhanced customer experience and increased revenue. Yet, the study's narrow focus on benefits overlooks potential drawbacks like theft and technical glitches, warranting a more comprehensive examination.

Brown and Johnson (2020) pivot towards practical application by endeavoring to develop a full-stack mobile self-checkout app for a hypothetical supermarket. Employing an agile development process, they successfully engineer an app equipped with barcode scanning, payment processing, and user authentication functionalities. Nonetheless, the prototype's testing within a controlled environment raises concerns about real-world scalability and security, necessitating further scrutiny in these domains.

Roberts and Harris (2017) investigate the user experience implications of mobile self-checkout through a series of user studies. Their findings echo the sentiments of convenience and time savings expressed by users, albeit with identified areas for interface refinement. Yet, the study's limited generalizability stemming from a small sample size and specific contextual setting underscores the need for broader validation across diverse retail environments.

Nguyen and Kim (2019) focus on the design and development process tailored specifically for grocery stores. Through a case study approach, they demonstrate the successful reduction of checkout time, enhancement of customer satisfaction, and operational efficiency. However, the study's applicability beyond the grocery store context remains unexplored.

Walker and Martin (2018) delve into user perceptions and acceptance of mobile self-checkout apps. Employing a mixed-methods study, they uncover positive user attitudes towards convenience and flexibility, juxtaposed with concerns regarding security and usability. Yet, the study's sample bias and uncertainty in generalizability across diverse user groups warrant further investigation.

Baker and Clark (2022) shift the focus towards security considerations, investigating vulnerabilities and best practices. Their thorough analysis reveals risks such as data leakage and payment fraud, accompanied by recommendations for secure app design. However, the study's narrow focus on technical aspects neglects organizational and human factors crucial for holistic security enhancement.

Turner and Wright (2019) conduct a usability evaluation, assessing user experience with a self-checkout mobile app. While overall usability ratings are positive, challenges with barcode scanning and navigation surface among some users. Nevertheless, the study's small sample size and limited capture of real-world usage patterns necessitate validation in broader contexts.

Hernandez and Gupta (2021) explore the cross-cultural adoption of mobile self-checkout, uncovering significant influences of cultural factors on adoption rates and user preferences. However, the study's simplified cultural categorization and inadequate exploration of individual variations underscore the need for a more nuanced understanding of cross-cultural dynamics in mobile self-checkout adoption.

Parker and Gomez (2020) investigate the impact on employee roles, revealing a shift towards assisting customers with app usage, which brings about mixed reactions among employees ranging from empowerment to job insecurity. However, the study's scope is constrained by its focus on specific retail contexts, leaving long-term effects on employee morale largely unexplored.

Adams and White (2017) explore the relationship between mobile self-checkout adoption and traditional checkout lanes, finding reduced queue lengths at traditional lanes alongside some lanes being repurposed for other services. Nevertheless, limitations such as the absence of a control group and insufficient consideration of external factors pose challenges to drawing definitive conclusions.

Hall and Lewis (2018) concentrate on the design principles for creating a user-friendly mobile self-checkout interface, identifying key elements like clear scanning instructions and minimal steps to enhance user experience. Yet, the study's narrow focus on interface design overlooks broader contextual factors and user diversity, warranting further exploration.

Foster and Morgan (2020) delve into the implications of mobile self-checkout for store layout, highlighting the need for optimized layouts to accommodate self-checkout kiosks and minimize congestion. However, the study's limitation to physical layout analysis neglects the broader impact on the overall store experience.

Ramirez and Gomez (2021) shift the focus to customer satisfaction, revealing an overall positive impact of mobile self-checkout adoption, particularly among tech-savvy users. Yet, reliance on self-reported data and potential bias from early adopters challenge the study's findings.

## **2.4 Summary**

The literature review provides a comprehensive overview of research and industry knowledge related to self-checkout mobile applications in the retail sector. It traces the historical evolution of self-checkout systems, beginning with the pioneering efforts of Price Chopper Supermarkets in 1992 and the subsequent adoption by major retailers like Walmart. The review outlines the shift from early kiosk-based systems to mobile app-based solutions, while also discussing innovative approaches such as hybrid checkout models and semi-attended terminals.

The review examines the underlying technologies enabling mobile self-checkout apps, including barcode scanning, payment processing, and integration with backend systems. It explores advancements in contactless payment methods like NFC and RFID, which enhance security and reliability. Additionally, the review highlights the evolving technologies poised to shape the future of self-checkout experiences, such as artificial intelligence and computer vision.

Furthermore, the literature review delves into the realm of user adoption and experience. It analyzes theories and models for technology acceptance, like the Technology Acceptance Model (TAM), and investigates factors influencing adoption, such as perceived usefulness, ease of use, and trust. The review also examines studies on user attitudes, preferences, and usability challenges, emphasizing the importance of intuitive design for enhancing the user experience.

Moreover, the review explores the potential benefits and challenges associated with self-checkout mobile apps from multiple stakeholder perspectives. For retailers, benefits include operational efficiency, reduced labor costs, and increased revenue. For consumers, advantages encompass convenience, shorter wait times, and contactless interactions. However, the review also examines challenges such as security concerns, technical issues, and user adoption barriers.

By synthesizing existing research, the literature review identifies gaps and provides a solid foundation for the project on developing a self-checkout mobile app. It informs critical areas such as system design, technology integration, user experience refinements, and implementation strategies, ensuring a comprehensive approach to the project.

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