

**Wearable Payment Devices as a Financial Technology Innovation:
Advancing Digital Payments and Financial Inclusion in China****BOUGOUFFA Lina ^{1♦}, GHERIBI Ahmed ²**¹ Sustainable Local Development Laboratory, University of Yahia Fares, Medea (Algeria),
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(Algeria), Gheribi67@yahoo.fr.**Received:** 05/03/2025**Accepted:** 20/05/2025**Published:** 25/05/2025**Abstract:**

This study describes how wearable devices help promote digital payments and advance financial inclusion in China as a financial technology innovation. It aims to analyze the factors influencing their adoption and their effects on the broader financial ecosystem. The research adopts a descriptive-analytical method, referring to scientific literature, financial reports, and official data sources such as Statista and regulatory agencies. Findings have identified major adoption drivers such as security enhancement via blockchain technologies, building consumer trust, and the deep penetration of smartphones. These developments have further propelled the rapid growth of these technologies in China, establishing the country as a world leader with more than 85% of mobile transactions in its market. Although in the past, there have been issues with the early security problems involved with technology contributing to apprehension among consumers, further adoption was encouraged through integrating blockchain technology and biometric authentication. The study recommends that financial inclusion through innovations in digital payment could be enhanced worldwide, whereby other nations can learn from China's experience.

Keywords: Wearable Payment Devices, Financial Technology, Digital Payments, Financial Inclusion, Blockchain Security.

JEL Classification: O33, G23, E42, G28, G32.

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1. Introduction:

Financial technology continues to grow in light of rapid technological transformations, which are raising great attention in multiple areas, including payment systems. One of the most prominent modern innovations in this field is the emergence of payments through wearable devices, which are one of the most notable emerging applications in the era of digital payment (Lee, Hew, Leong, Tan, & Ooi, 2020). These devices, which include smartwatches and smart bracelets ... have helped accelerate the pace of the transformation towards a non-critical world, as it provides an unimaginable payment experience and allows transactions at any time and from anywhere (Niknejad, Waidah Binti, Mardani, & Liao, 2020).

The integration of wearable device technology in the banking sector has been particularly notable, owing to its advanced biometric authentication capabilities and user-friendly adoption process. Several banks now support credit card integration with applications such as Fit Pay and Apple Watch, while others have introduced contactless wristbands that facilitate installment-based payment solutions (Alladi, Chamola, Sikdar, & Choo, 2020). These innovations have not just improved payment efficiency; they are also ways of widening financial inclusion because they tend to make digital access to financial services easier, especially for the unbanked and underbanked. Thus, they become less reliant on the usual banking infrastructure and allow even smoother transaction transitions. Backup portable payment devices operate as they have become entry points to participatory finance (Bojjagani, et al., 2023)

Although the global adoption of this technology is still in its early stages, there is an increasing interest from banks and technological companies to encourage the use of this technology among consumers (Ahmad, 2017). The main advantages of these payments lie in the comfort and efficiency they offer users, which improves the user experience and enhances the growth of digital transactions (Leong, Teck-Soon, Ooi, & June, 2020). Moreover, the widespread availability of smart devices has further facilitated the adoption of wearable payment technology across various markets (Ali & Li, 2019). This context makes room for financial inclusion, in the sense that wearable payment services can break the gap between what one can get through traditional banking and what can be offered through digital financial services and allow a greater segment of society to utilize safer and highly efficient payment methods (Bojjagani, et al., 2023).

Several leading countries have embraced this technology, continuously developing and promoting wearable payment systems to align with the evolving needs of digital consumers. These nations provide innovative models that can serve as benchmarks for other countries seeking to integrate this technology into their payment infrastructure. This has created a strong case study for understanding how fintech innovations have made their case in promoting financial inclusion. China has particularly pioneered the integration of wearable payment devices in a digital finance context.

In light of the above, the following key research question emerges: **How have wearable payment devices, as an innovation in financial technology, contributed to the development of digital payments and the expansion of financial inclusion in China?**

1.1 Significance of the Study :

This study becomes significant as it immediately engages financial technology, wearable payment innovation, and financial inclusion. Specifically, China's experience shows how technology can contribute to closing financial gaps or giving more access to digital payments. It offers insights that may benefit policymakers, Fintech developers, and financial institutions interested in expanding wearable payments and enhancing financial accessibility for underrepresented populations.

1.2 Objectives of the Study:

- To give a complete overview of wearable payment devices, their development, and their role in digital payments;
- To analyze the advantages, disadvantages, and security elements associated with wearable payment technology;
- To explore the interplay between wearable payment innovation and blockchain technology and its effects on security;
- The study intends to assess the extent to which China has progressed regarding wearable payments and the contribution made to financial inclusion.

1.3 Research Methodology:

This study employs a descriptive-analytical approach, which draws on scientific literature, industry reports, and official sources on finance and technology, especially in China. It has a structured approach: it develops a theoretical framework by studying fundamental concepts of fintech, such as financial technology, digital payments, and wearable payment devices; then it discusses what wearable payment devices are, their

importance, their advantages, historical development, types, payment mechanisms, security features, and current global market trends.

Furthermore, the study investigates the introduction of blockchain technology in wearable payments and its role in security and trust. The empirical analysis draws on experience from China and mainly references primary sources within Statista and financial institutions, fintech reports, and regulatory agencies. A quantitative and qualitative assessment on determining the trends in their adoption and the main influencing factors for the extensive diffusion of wearable payment solutions across China is also carried out. By synthesizing insights from existing literature and real-world data, this study provides a comprehensive perspective on the impact of wearable payment devices on financial inclusion and explores how financial technology innovations have addressed adoption challenges.

1.4 Review of Related Literature:

Earlier studies conducted on wearable payment technologies uncovered important adoption incentives, challenges relating to security, and trends in innovation, providing insights into research gaps and future developments. The study by **(Lee, Hew, Leong, Tan, & Ooi, 2020)** investigated the influence of perceived aesthetics, technological readiness, mobile device benefits, and ease of use on behavioral intention to adopt wearable payment technologies. Their study found that all hypothesized relationships were supported except for the link between ease of use and behavioral intention. The researchers employed a dual-analysis approach using deep learning, providing insights that enhance marketing strategies for payment service providers and wearable device manufacturers. Similarly, **(Hidayat-ur-Rehman, Ahmad, Akhter, & Rehman, 2022)** explored consumer adoption of wearable payment technologies in Saudi Arabia using a questionnaire-based survey. Their findings supported all hypothesized relationships, except for the relationship between compatibility and perceived ease of use. Moreover, the study emphasized the role of personal innovativeness as a moderating factor between behavioral intention and actual usage. From a technological perspective, **(Bojjagani, Venkateswara, Vemula, Reddy, & Lakshmi, 2022)** proposed an IoT-based Micro Pushing Protocol tailored for the wearable payment ecosystem. Their model incorporated an Elliptic Curve Integrated Encryption Scheme (ECIES) to secure message exchanges between different parties, enabling consumers to conduct transactions securely via wearable devices. Security analyses confirmed the

protocol's robustness against potential threats associated with mobile payments. In a subsequent study, **(Sriramulu, et al., 2023)** introduced a three-factor authentication system, providing enhanced encryption mechanisms to ensure the security of proximity and remote wearable payments.

Regarding workplace adoption **(Schwambach, Sott, & Schwambach, 2024)** conducted a biometric review using complex network analysis to examine employees' perceptions and acceptance of wearable technologies. Their findings indicated an increasing adoption trend and identified key factors influencing acceptance or resistance in the workplace. The study underscored the importance of organizational and technological factors in facilitating effective implementation, while also highlighting that the lack of employee involvement in device selection remains a major barrier to adoption.

In the realm of blockchain-enabled wearable payments, **(Maimunatu, Kabiru, Aminu, & Yakubu, 2024)** developed a secure blockchain-based payment system to enhance transaction security and protect personal data. Their study confirmed that blockchain technology strengthens transaction security by providing immutable records, thereby increasing trust and confidence in wearable payment systems.

➤ This study aligns with previous research on fintech adoption, which emphasized perceived benefits, ease of use, and security in their study of influencers on adopting digital payments. Previous studies have assessed user acceptance toward mobile and wearable payment methods and the technological implementation of security measures like encryption and authentication mechanisms. However, this study differs by examining China's leadership in wearable payment adoption, integrating blockchain technology for enhanced security, and analyzing its role in expanding financial services rather than addressing financial exclusion. With 85% of digital transactions in China relying on mobile and smart payment systems, this study provides empirical insights into the country's success and offers lessons for global adoption. It bridges a gap by combining theoretical perspectives with real-world implementation, highlighting how fintech innovations enhance financial accessibility and trust in advanced economies.

2. Theoretical Framework:

This section outlines the foundational theories and models that underpin the study, providing a structured analysis of key concepts related to wearable payment technologies.

2.1 Financial Technology (FinTech):

Financial Technology (FinTech) encompasses financing services designed to meet technological needs and is widely applied across various sectors (Adalet & Babuşcu, 2023). It is a technological financial innovation that can lead to new business models, applications, processes, products, or services with a material impact on markets and financial institutions (Anshari, Almunawar, & Masri, 2020). Rather than focusing on specific techniques that may change over time, financial technology emphasizes market trends and the regulatory effects of digital transformation in accelerating economies (Feyen, Natarajan, & Saal, 2023). The payments sector is one of the most prominent beneficiaries of financial technology, particularly in bill payments, e-wallets, and online transactions. This technology has enhanced access to payment services, improving their efficiency and effectiveness in daily financial operations (Ougasm & Hamdi, 2019).

2.2 Digital Payments:

Digital payments refer to payment transactions made using electronic devices like computers, mobile devices, and other digital platforms to transfer funds, pay for goods, or settle transactions over the Internet. Typically, such payments use secure systems, including payment gateways, digital wallets, and mobile payment applications. Digital payments have improved in speed, convenience, and safety over traditional ways by eliminating the use of physical cash (Pavlo, 2018).

2.2.1 Fintech tools supporting digital payments:

The digital payment chain owes everything to fintech tools that ensure the transaction is carried out speedily and securely. High on the list of tools is the mobile payment system—the ultimate method of transferring money between peers and enabling cross-border commercial transactions. So states a report published by Mordor Intelligence, whereby the expected size of the mobile payment market in 2024 will be \$94.51 billion, growing at an annual rate of 34.04% during the period from 2024 to 2029. Applications such as PayPal, Venmo, and Square Cash provide efficient alternatives to conventional banking systems (Mordor Intelligence, 2024).

2.2.2 Innovations in digital payment methods:

Another critical tool is the e-check, which works mainly like the traditional paper check but via an electronic environment, ensuring swifter and more efficient payment processing. Thus increasing the security of the transaction while decreasing operational costs (Adalet & Babuşcu, 2023).

Digital wallets are another important innovation that allows consumers to make purchases through smart devices such as smartphones. Such wallets securely store payment information by linking it to bank accounts and cut down on the need for physical wallets (Asmaa Mohmmmed, 2024). Further, contactless payment mechanisms leverage RFID or Near Field Communication (NFC) technologies to conduct safe transactions with a mere tap of the card or device on, or near, a compatible payment terminal. This trend, often referred to as tap-and-go, is suggested to have sped transaction processes and improved customer convenience in shops (Kagan, 2020).

2.3 Wearable payment devices:

Wearable payment devices represent an innovative advancement in financial technology, offering users a seamless, secure, and contactless payment experience through smart accessories.

2.3.1 The concept of wearable payment technology:

a. Definition and characteristics of wearable devices:

Wearable devices, also known as wearable technology, can be defined as advanced computing technologies that the user can wear (Jacobs, et al., 2019). With user data tracking and recording devices (Wang, 2015). Smart wearable devices are also "technologies that make technology use personal and easy by integrating wireless communication, advanced electronic circuits, and independent processing capacity that is integrated into designs that wear on the user's body" (Lee, Hew, Leong, Tan, & Ooi, 2020).

b. Functional advantages and user interaction with wearables:

Wearable devices offer an unrestricted experience, allowing users to operate them without using their hands, enabling multitasking. They are also controllable, giving users the ability to manage them at any time. Equipped with multiple sensors and various work modes, these devices maintain user attention by adapting to different conditions. However, they can also be confusing, as they provide alerts, reminders, or messages that may continuously demand the user's focus. In terms of communication, wearable devices can exchange information wirelessly while remaining non-dominant, meaning users can stay

engaged in their activities without needing to focus on the device (Ching & Singh, 2016). According to (Tarabasz & Poddar, 2019), wearable technology integrates four key technological trends: mobile communication channels, the Internet of Things (IoT), augmented reality (AR), and big data.

c. Wearable devices in payment systems:

Wearable payment solutions are the use of wearable devices by users to pay for products and services permanently and travel. These devices are referred to as electronic and can be worn, and provide specific services, as they facilitate payments during navigation, which makes them similar to the idea of payments via mobile phones (Hidayat-ur-Rehman, Ahmad, Akhter, & Rehman, 2022). The widespread spread of wearable devices and technological developments in the Internet of Things (IoT) allowed users to make payments at any time and from anywhere, which led to the emergence of a new payment method known as the wearable payment (Niknejad, Waidah Binti, Mardani, & Liao, 2020), which is considered a form of mobile payment (Lee, Hew, Leong, Tan, & Ooi, 2020).

d. Use of NFC Technology in wearable payments:

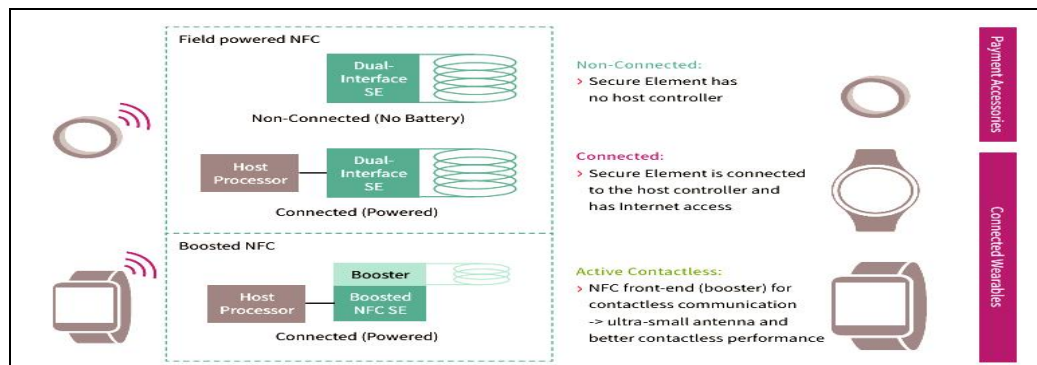
Wearable devices can also be defined as a type of infinite payment using the Near Field Communication (NFC) (Torsten J & Meinert, 2017). Near Field Communication is a short-range radio technology based on RFID and interconnection technology, and supports data exchange with compatible devices. It mainly supports payment and provides convenience for people's outgoing. For example, NFC technology can support the payment for taking public transport (Ondrus & Pigneur, 2007).

e. Advantages and classifications of wearable payment devices:

Wearable payment devices offer the following advantages, among others: convenience, security, and speed in performing transactions (Seneviratne, et al., 2017). It constitutes electronic payment systems categorized based on their level of connectivity and security. These devices are divided into two main categories: non-connected payment accessories, which lack a host processor and rely on Dual-Interface Secure Elements (SE) without an internal power source, making them suitable for specific environments such as large-scale events, and connected wearables, which incorporate a host processor and internet connectivity, enabling more advanced data management and dynamic authentication mechanisms. These systems utilize various communication technologies, including field-powered NFC, which can be either non-connected or connected to a host processor, and

boosted NFC, which employs an enhanced security element to improve wireless communication efficiency. These technological advancements reflect the evolution of payment solutions via wearable devices, where non-connected systems offer simple and fast solutions while connected systems provide higher levels of security and advanced functionalities (Infineon, 2021). This is illustrated in the following figure:

Fig.1. Mechanisms of NFC technology in wearable devices: passive and active contactless communication.



Source: (Infineon, 2021).

2.3.2 The development of wearable devices in digital payments:

The first devices of this type were developed in the 1960s when Thorp and Shannon created a wearable device to enter and predict the results of roulette using ear headphones (Thorp, 1998). Between 2006-2013, several wearable devices appeared on the market, but the real penetration in the market occurred in 2014 when the first Apple Watch was presented. Later, many industry services were considered in 2014, the year of wearable technology.

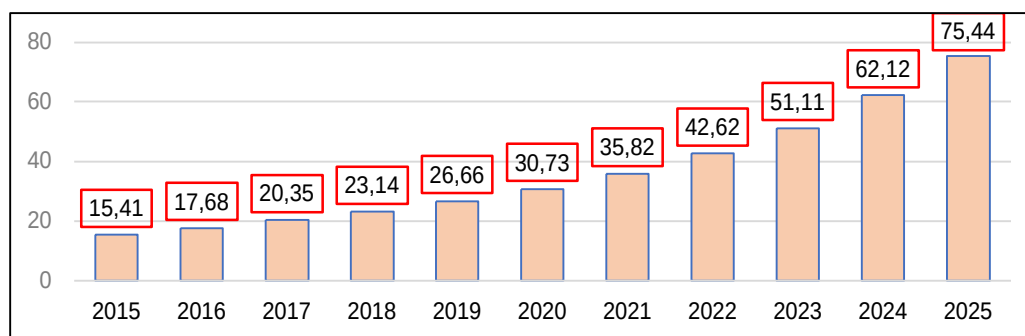
In 2015, Barclays expanded with innovative products such as payment bracelets, key chains, and smart posters, which enabled users to make payments via VISA or MasterCard. As a result, more than 100,000 units were sold and used in more than a million transactions with a value of 5 million pounds (Smart Payment Association, 2017).

Because of the health requirements and hygiene imposed by COVID-19 to avoid dealing with money, digital financial transactions have been adopted. In the last five years, wearable devices have been used, such as smart watches, bracelets, and health and fitness tracking devices, for rapid growth (Ali & Li, 2019). It is expected that the market for these devices will continue to grow globally (Niknejad, Waidah Binti, Mardani, & Liao, 2020), and recent years have also witnessed a remarkable development in wearable payment techniques, as smartwatches and fitness-equipped fitness -equipped fitness devices have become Tousse is one of the most used means in global markets. Among the most prominent

of these devices are the Apple Watch, which supports Apple Pay, and the Samsung Gear S2 equipped with Samsung Pay, as well (Smart Payment Association, 2017).

The graph below illustrates the global growth of devices connected to digital payments during the period from 2015 to 2025, which highlights the great development of these devices in the market:

Fig.2. Global Growth of Connected Devices for Digital Payments (2015–2025) (in billions).



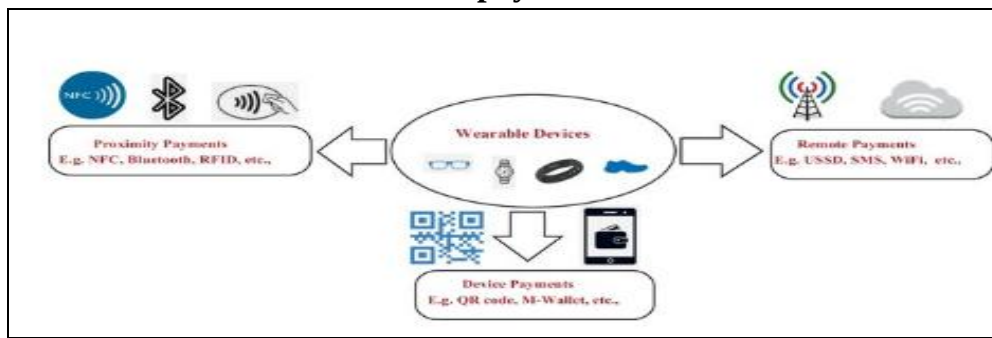
Source: (Statista Research Department, 2024).

The previous graphic shows an accelerated growth rate of globally connected devices from 2015 to 2025, with the increase of devices from 15.41 billion in 2015 to 75.44 billion by 2025. This growth directly parallels the current trends in digital transformation and Internet of Things (IoT) development in other areas, such as the financial environment and digital payments. It is noted that the growth rate in recent years (2020-2025) appears to be faster compared to the period between 2015 and 2020, indicating advanced developments in the areas of artificial intelligence, the Internet of Things, and automation.

2.3.3 Types of wearable payment solutions:

Wearable devices are an advanced means of electronic payment, as they allow users to make financial transactions easily and safely. These devices include smart watches, bracelets, and rings equipped with near-range communication technology (NFC), allowing the completion of payments once the device is closer to a compatible reader (Hidayat-ur-Rehman, Ahmad, Akhter, & Rehman, 2022).

Fig.3. Classification of wearable payment methods: proximity, remote, and device-based payments.



Source: (Bojjagani, Venkateswara, Vemula, Reddy, & Lakshmi, 2022).

According to the figure, there are three main ways to pay via wearable devices:

- **Proximity Payments:** depends on technologies such as NFC, Bluetooth, and RFID, where the wearable device is in contact with the payment reader (Bojjagani, Venkateswara, Vemula, Reddy, & Lakshmi, 2022). For example, the Commercial Bank in Qatar has launched a service that allows customers to make payments using smartwatches and NFC sports trackers (zoom32, 2024);
- **Device Payments:** carried out using the QR or e-wallets (E-wallets), such as applications that support via mobile phone or wearable devices;
- **Remote Payments:** depend on the Internet, SMS, or Wi-Fi, where the payment is done without the need for direct contact, such as online financial transfers using wearable devices. Softpos technology converts NFC mobile phones into electronic payment devices, allowing traders to accept payment operations without contact directly via their phones (FasterCapital, 2022).

2.3.4 Identity and security management through wearable devices:

Since banks are still responsible for the payment tools they issue, they must protect the identity of customers, just as they did when the cards were released, through the process of knowing your customer (KYC) (Luyao, et al., 2022). With the increasing use of wearable smart devices, the focus is no longer limited to the identity of the user but also extended to the identity of the device itself. The flow of revenues resulting from services connected to these devices, which are activated via smartphones using NFC technology, improves user experience and opens new horizons for business and distribution models, which helps to expand the scope of this market. In the process of issuing traditional payment cards, the safe element (the electronic chip) is managed centrally within the allocation centers of the smart cards, which is the same process that is often applied to unconnected wearable devices,

making their repetition a simple matter. As for the connected wearable devices, digital accreditation data management, such as a definition or payment codes, often takes place via the smartphone, which is connected to these devices through (BLE) technology. To ensure the safety of this process, a set of security measures should be carried out that enhance data protection and limit any possible digital threats (Steve, 2022).

2.3.5 Blockchain technology in developing a safe payment system for wearable devices:

a. The role of blockchain in enhancing financial transaction security:

Blockchain is a safe and transparent technique for storage and transportation, operating without a central control device, which can be used to transfer data from point A to point B. It is a distributed database, which runs a list of mechanically protected records, against tampering or modification by storage in the contract through the decentralized schedule (Dominique, 2017). The use of blockchain technology in wearable devices is an important step in providing a high level of safety for financial transactions. By applying an integrated security class, the proposed system provides basic security elements such as strong approval, data safety, secrecy, and non-denial, which enhances the protection of financial transactions and prevents manipulation. (Bojjagani, Venkateswara, Vemula, Reddy, & Lakshmi, 2022).

b. Addressing financial risks and system vulnerabilities:

This system contributes to avoiding problems such as double and excessive spending, as well as reducing money laundering operations, which improves the effectiveness of the financial system and ensures the confidentiality of financial information. The system is also validated using blockchain technology to counter electronic attacks, which enhances the reliability of the system in protecting payments via mobile devices. Users can make purchases using wearable devices, with payment data entered via protected mobile applications. Although there are some safe authentication solutions for wearable devices, many of them lack servers and depend only on the techniques of connecting the wearable device to the mobile device, which limits safety in some cases.

c. Blockchain integration across payment ecosystems:

By using blockchain technology, comprehensive protection is provided between mobile devices, wearable technologies, payment gateways, banking institutions, and the financial technology sector. Looking at the sensitivity of the financial data and being vulnerable to electronic attacks, technology depends on ensuring the protection of the

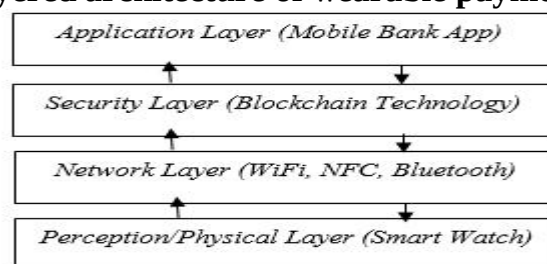
exchanges of payment data and financial records (Maimunatu, Kabiru, Aminu, & Yakubu, 2024).

d. Architectural design of a secure blockchain-based wearable payment system:

Blockchain technology provides essential security properties, such as immutability, distributed ledgers, decentralized storage, and advanced authentication, which contribute to enhancing security in the Internet of Things (IoT) environment. These properties are applied in designing a secure payment system that enhances the integration of security and innovation in the digital payments sector, providing an effective solution to the security vulnerabilities in wearable payment systems (Jain, Yadav, & Shrivastava, 2019). Each architectural layer in the proposed blockchain-based wearable payment system aims to provide maximum security and functionality. Mobile applications will serve as the user interface at the application layer, enabling seamless interactions for account management, payment processing, and transaction authorization. This application will provide real-time notifications and insights on each transaction initiated from the wearable device. At the security layer, robust and immutable transaction records will be ensured through the use of blockchain technology. The immutable data records provided by the blockchain's distributed ledger ensure that each transaction is secure, traceable, and protected against fraud. Technologies such as WiFi, Bluetooth, or NFC will be used at the network layer to establish communication between the wearable device and the banking system. These technologies ensure efficient data transfer, whether the wearable device is used for contactless payments near the hand or remotely. To enhance security through biometric identification, the sensory/perceptual layer will also include a wristwatch equipped with biometric sensors such as fingerprint or facial recognition. Advanced application, security, and network technologies work together to provide a secure, efficient, and user-friendly wearable banking solution (Maimunatu, Kabiru, Aminu, & Yakubu, 2024).

The following figure summarizes the aforementioned points:

Fig.4. The layered architecture of wearable payment systems.

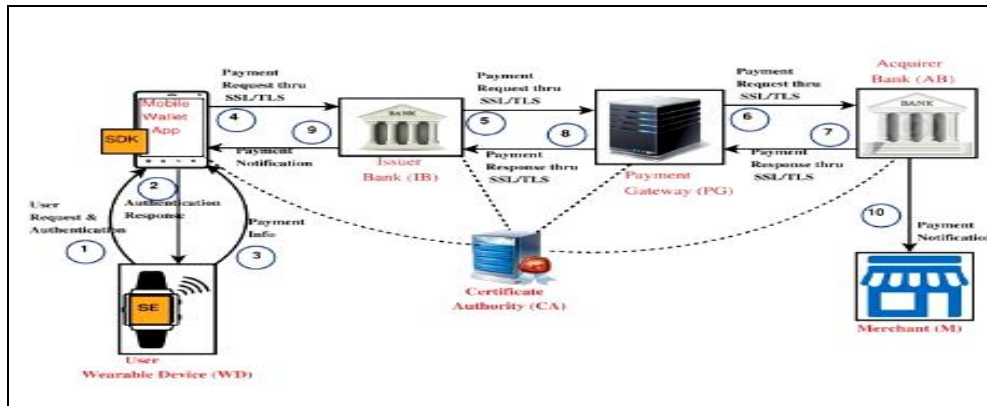


Source: (Maimunatu, Kabiru, Aminu, & Yakubu, 2024).

2.3.6 The stages of the payment process via the wearable device:

The payment flow uses wearable devices, where an integrated mobile wallet in the wearable device (such as a smartwatch) is used to securely process an online payment transaction. The process can be summarized as follows:

Fig.5. Stages of the Payment Process via Wearable Devices.



Source: (Bojjagani, et al., 2023).

- **Transaction Initiation:** The user performs the wearable device;
- **Authentication:** A certificate request is sent to the mobile app (Mobile Wallet App) to check the user's identity;
- **Sending Payment Information:** After the approval success, the payment data is sent to the source bank (ISSUER Bank - IB);
- **Payment notification:** The source bank is notifying the Payment Gateway with treatment information via a secure connection (SSL/TLS);
- **Certificate Authority (CA) Verification:** Data is examined and security certificates are validated to ensure treatment of treatment;
- **Payment Request to the Acquirer Bank:** Payment data passes through the payment portal;
- **Acquirer Bank Notification:** The acquiring bank processes the transaction;
- **Payment Gateway Response:** The payment portal response is sent to the source bank to inform it of the result of the transaction;
- **Merchant Notification:** Once the transaction is approved, the merchant is notified of the completed payment;
- **Transaction Completion:** The final payment notification is sent to the merchant, completing the transaction.

2.4 The role of wearable payment devices in transforming digital payments and financial inclusion:

Digital payment technologies have had a two-way transformation on conventional economic *modus operandi* by cash-based transactions. Even today, the technologies continue to oblige the availability of a variety of financial services, including transfers of money, savings, insurance, credit, etc., in a *modus operandi*-accommodating fashion that promotes responsible financial inclusion. It has gradually changed the financial system of any country that has adopted them. It has impacted financial inclusion by allowing different segments of life—e.g., the elderly and persons in rural areas—to gain easier access to financial services (Heriat & Abdelli, 2022).

2.4.1 Expanding access to financial services:

The wearable payment goods comprising smart payment wristwatches and wristbands are interestingly fun and continue to encourage the development of innovative digital payment solutions. In doing so, the gadgets access the financial services of such unbanked individuals, enhancing their full integration into the formal financial system (World Bank Group, 2020).

2.4.2 Enhancing Security and Trust in Financial Transactions:

Wearable devices also go further by using advanced authentication modes, like biometric fingerprint or facial recognition, which increase transaction security. This added security makes these technologies more palatable to a larger number of people and thus fosters greater financial inclusion (Kim, 2023).

2.4.3 Supporting Marginalized Groups:

People who find traditional banking technologies difficult to use, such as the elderly and disabled, will find such wearable payment appliances as one of the more accessible financial solutions. With friendly designs, these devices allow the easy and safe execution of financial transactions (Pedro, Marion, Hikaru, & Michele, 2024).

3. Enhancing Financial Inclusion in China through Wearable Payment Technologies:

Wearable payments are rapidly evolving in leading countries, driven by technological advancements and the expansion of digital financial infrastructure. These experiences reflect diverse strategies for adopting and developing this technology within banking systems. These innovations contribute to financial inclusion by providing more accessible, efficient, and secure payment solutions, reducing dependence on cash and traditional banking services.

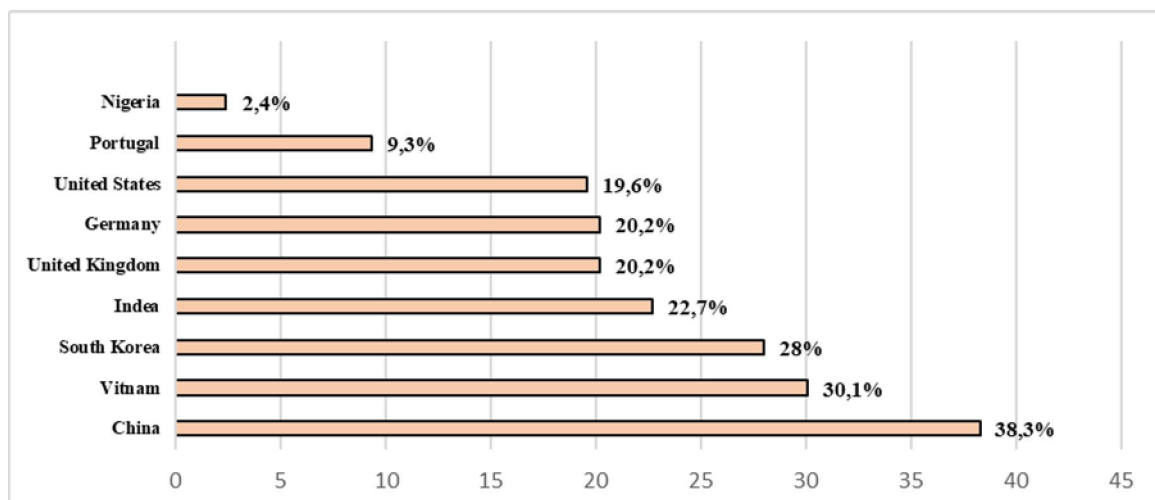
3.1 China as a Pioneer in Digital Payment Adoption:

Surveys conducted in 2019 revealed that 67% of customers relied on mobile payments, with notable increases recorded in Thailand (19%), Vietnam (24%), and Middle Eastern countries (Aji, Berakon, & Md Husin, 2020). Like other parts of the globe, China enjoys quite a large adoption of mobile payments among smartphone users. However, compared with many other nations, the adoption rates are very high by all the measures, given that it constitutes up to 81 % of the total users at a global level. The number of users has swollen to 853 million by the end of December 2020, according to the 47th Statistical Report on Internet Development in China: 86.5 percent of all mobile internet users in China (Achille, et al., 2021)

This upward trend further confirms China's continued dominance in this area with a narrative toward a more fully integrated digital economic landscape. This trend is further confirmed by a report issued by iiMedia Research, which indicated that mobile payments were the primary payment means for Chinese consumers in the year 2024, accounting for 73.20% of total transactions, above cash (63.46%) and physical bank card withdrawals (46.40%).

The wearable devices further enhance digital payment civilization among consumers, where more than a tenth (14.06%) use smartwatches for payments (Daxue Consulting China, 2024). The following figure illustrates China's global leadership in mobile payment adoption, ranking first in user penetration and transaction values in the mobile point-of-sale (POS) sector in 2023:

Fig.6. User penetration rates and transaction values in the mobile point-of-sale (pos) sector in 2023.



Source: (Daxue Consulting China, 2024).

The previous figure illustrates the disparity between mobile payment penetration rates and the average annual transaction value per user across different countries.

As of 2023, China is at the forefront of the mobile payment trend worldwide. The country has a high penetration of 38.3% as displayed in the figure, the highest among the nine sampled countries. The rise in popularity of payments using WeChat Pay and Alipay has changed payment behavior for retail, dining, and e-commerce. This rapid transformation is supported by the peculiar business ecosystem of China with a large number of small businesses which allowed the country to leapfrog credit cards and move directly to digital payments.

After China, major digital payment markets include Vietnam (30.1%) and South Korea (28%). Still, the transaction values do not follow the penetration rates directly. In other words, despite the adoption rates being lower, the United States (\$9,860) and the United Kingdom (\$9,340) are the ones that spend the most on average compared to other nations. This signifies that in developed countries digital payments are chosen primarily for high-value transactions, whereas in developing nations such as India (\$106) and Vietnam (\$99) mobile payments are predominantly used for relatively inconsequential day-to-day purchases.

Countries such as Portugal (9.3% penetration and \$3,070 annual transaction value) provide specific examples of focused yet substantial use of digital payments within specific segments of consumers.

These divergences underscore the contribution of financial infrastructure, levels of income, and culture of consumption in the global market penetration of mobile payments. By expanding access to wearable payment solutions, financial inclusion is enhanced, enabling people with limited access to banking services to participate in the digital economy.

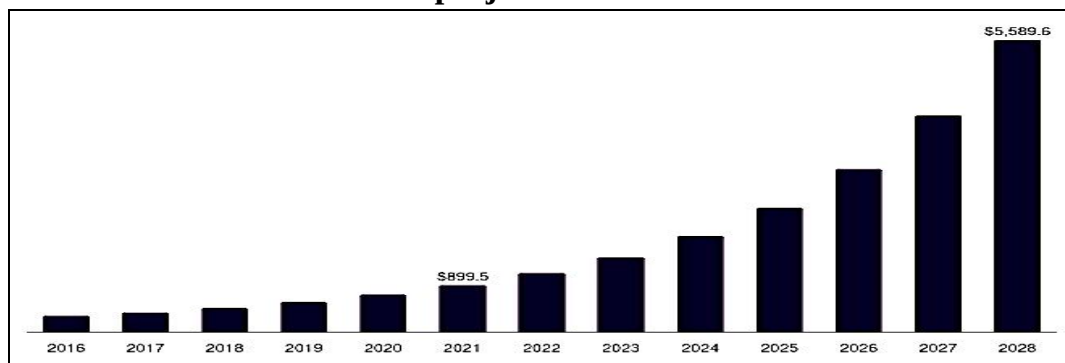
3.2 Growth of the wearable payment market in China:

The popularity of wearable payment devices is increasing due to advanced technology, which provides a fast, convenient, and secure payment experience across various environments (Bezhovski, 2016). These devices have been globally recognized as one of the most significant Internet of Things (IoT) products, with sales exceeding 141 million units in 2019 (Park, 2020).

According to the (Horizon Grand View Research, 2024) report, revenue from China's wearable payment market reached \$899.5 million in 2021 and is projected to grow to \$5,589.5 million by 2028. The market is expected to expand at a compound annual growth rate (CAGR) of 29.8% during the 2022–2028 period.

At the sectoral level, fitness trackers held the largest revenue share (42.83%) in 2021. However, smartwatches represent the fastest-growing segment, expected to achieve the highest growth rate over the forecast period. The following figure illustrates this trend:

Fig.7. The wearable payment market in China (2016–2028) (Million USD) – trends and projections.



Source: (Horizon Grand View Research, 2024).

3.3 Types of Chinese Wearable Devices:

Wearable devices have made phenomenal advancements in China since they have now found relevance in everyday lives for most users. These gadgets have transcended normal fitness functions to include payment capabilities. They're integrating with digital wallets and contactless payment methods. By offering accessible payment alternatives, these devices bridge financial gaps for unbanked and underbanked populations.

3.3.1 Smartwatches:

- **HUAWEI WATCH:** The 2024 IDC Wearable Device Market Tracking Report indicates global shipments of all wrist-worn wearables were in decline, whereas the Chinese market sustained a vigorous growth rate of 20.1% in just the last year, adding significantly to global growth. For its part, Huawei commentary has seen a whopping 44.3% rise in global shipments in one year, scoring a market-leading position by getting 16.9% shares globally and 35.7% in China. On the one hand, this was propelled by the introduction of the flagship HUAWEI WATCH FIT 3, HUAWEI WATCH GT 5, and HUAWEI WATCH D2, all of which allow for NFC

payment technology which will enable users to transact straight from the wrist (Wilson & Tolga, 2024);

- **Apple Watch:** In China and beyond, Apple Watch is extremely popular and has been seamlessly integrated with Apple Pay. This watch allows users to make secure and contactless payments at retail outlets, restaurants, gas stations, taxis, and other payment-enabled spots (Raynor, 2024). Apple Watch rules out the need to take out a phone or wallet and offers the ultimate convenience to users starting to explore wearable payment technology (Mohamed Hamed, 2024);
- **Samsung Galaxy Watch:** Samsung Galaxy Watch sets out to provide a smooth payment experience and becomes an independent payment device once set up. Users can simply use these capabilities with Samsung Pay to make secure contactless transactions at numerous POS terminals, lessening the need for a smartphone or a physical bank card (Mohamed Hamed, 2024).

3.3.2 Fitness Trackers:

These digital payment functionalities enhance fitness trackers' use beyond medicine. Some key models are: the Xiaomi Mi Band Series Which supports Mi Pay, and the Huawei Band Series: Which supports Huawei Pay.

3.3.3 Smart Rings:

Smart rings appear to be a fresh category in wearable payment technologies. That said, they offer small and smart payment solutions. Examples are: McCLEAR RingPay which Supports UnionPay (Mohamed Hamed, 2024).

3.4 Major Companies in the Wearable Payment Devices Industry:

According to the Strategic Assessment Report on China's Wearable Devices Market (2025-2031) and Its Prospects, based on the competitive landscape, the top five manufacturers in the wearable payment devices industry in terms of shipments are Apple, Imagine Marketing, Xiaomi, Samsung, and Huawei. Together, their market share exceeds 50%, indicating a relatively high industry concentration.

Among them, Apple ranks first in shipments, holding a 20.2% market share, followed by Imagine Marketing, Xiaomi, Samsung, and Huawei (Zhiyan Consulting, 2024). Their investments in wearable payment technologies contribute to financial inclusion by making digital transactions more accessible, secure, and convenient

3.5 Challenges in Adopting Wearable Payment Devices and Their Impact on Financial Inclusion:

Based on recent research in China, the adoption of wearable payment devices (WPD) remains at an early stage. Despite the growing interest in these devices as an alternative to cash, cheques, and traditional payment cards, the wearable payment technology sector is still evolving. A study by (Luyao, et al., 2022) investigating the intention to adopt WPD in China highlighted key factors such as perceived trust, lifestyle compatibility, and perceived ease of use that significantly influence consumer intentions. The findings revealed that factors like perceived trust, functionality compatibility, performance expectations, lifestyle compatibility, and habit formation played a crucial role in shaping Chinese consumers' adoption of wearable payment devices. Interestingly, ease of use was found to have less impact on adoption intention (Zhiyan Consulting, 2024).

3.5.1 Risk Management of Wearable Payment Devices:

The advent of wearable payment devices in China calls for effective risk management strategies to be adopted. Most of these devices have a financial database in their systems and subserviate transactions just by a simple wrist tap through Alipay and WeChat Pay. While these systems offer much convenience, concern about growing financial fraud continues to mount (Chang, Xin, Wong, & Mendez, 2019).

3.5.2 System Vulnerabilities and Cybersecurity Threats:

Cybersecurity threats are pertinent in China's digitized economy, and they bear some risks for the wearer of payment (Chang, Xin, Wong, & Mendez, 2019). Fraud or criminal activity can be enacted through a combination of system vulnerabilities found in smartwatches and fitness bands, which are employed to process financial transactions, methods of Bluetooth interception, and insecure cloud storage, and these may be malware attacks (Zhiyan Consulting, 2024).

An HP (2015) report initially acknowledged that many smartwatches were ill-equipped with strong forms of authentication and hence could be hacked. Since the user base of digital wallets in China is legion, issues of weakness in encryption protocols would gain favor from attackers who would invariably penetrate the systems and steal or induce fraudulent financial flow. According to research by (Sarkisyan, Debbiny, & Ani, 2015), most PIN codes are revealed by deducing the movement sensor data, a key issue in a market where mobile payments are imbued in daily transactions in China.

Formerly, thieves have also developed technical know-how on infesting wearable devices using malware, which could implicate attached smart devices like smartphones and computers (Richdec, 2023). In addition, as 5G networks expand rapidly in China, the risk that distance attacks may occur on smart devices used for payment increases (Homeland Security, 2023). The government has placed stricter laws on cybersecurity; however, there remains a headache in domestic implementation, especially after counterfeit devices came into the picture without security certification (Tim, Casey, & Ben, 2024).

3.5.3 Misappropriation of Data:

One of the burning ethical issues concerning wearable payment platforms in China is the collection and commercial misuse of users' data. They collect enormous amounts of their data gleaned from wearable payment transactions-location history, spending patterns, even biometric records, and many others that companies like Tencent or Alibaba make use of to improve a user experience while at the same time infringing on privacy rights and unauthorized third-party data-sharing (Junck, et al., 2021).

The FTC report (2014) outlined how tracking would be integrated into the advertising and marketing schemes of companies. In that sense, China shares similar stories regarding contracts between these technology companies and third parties such as advertisers. The Personal Information Protection Law developed and enacted by the Chinese government addresses many of the issues related to data collection and its appropriation. However, the implementation of this law lacks rigorousness for smaller manufacturers of wearable devices.

The integration of payment wearable devices with facial recognition technology is another controversial case regarding the misuse of data. While it improved the speed and efficiency of the payment process, many considered the technology as infringing on citizens' rights to privacy and as quite an advantage strike for the government to spy on citizens. Most Chinese consumers are worried that the biometric data of their identities will be taken without their consent by the authorities or service providers and will later be sold to third parties (Yu-li, Wenjia, & Bo, 2021).

3.5.4 Neglected Data Safety and Privacy:

While China has advanced much in technology, data security in wearable payment devices is usually a matter of overlooking. Most manufacturers of wearables talk about features and functionalities without talking about security.

A significant controversy arose when smartwatches with built-in GPS tracking were introduced in Chinese schools. While the intention was to improve student safety, the initiative was met with public criticism over privacy concerns (Chang, Xin, Wong, & Mendez, 2019).

4. Conclusion:

The study concludes that financial technology, as well as innovation in wearable payment devices, has advanced digital payments and financial inclusion in China. Through an elaborate review of the financial technology phenomenon, digital payments, and wearable payment systems, it is ascertained that China is ahead in the global market for mobile and wearable payments; 87% of consumers in China utilize digital wallets.

- According to the study findings, the strength of a rather developed fintech ecosystem is probably the most important factor attributed to China's success in this regard. On the current status of the payment landscape in China: According to the research study, 54% of payments are dominated by Alipay and 39% through WeChat Pay, both of which are available in wearable payment devices, as per data provided from the China Internet Network Information Center, 2023. These devices include smartwatches, smart rings, fitness bands, and NFC-enabled keychains, and they enable an easy and comfortable way for users to pay;
- Wearable payments are characterized by speed, ease of use, contactless transactions, and multi-device compatibility. Until 2028, the overall global market of WPD will be worth \$80 billion, with China contributing most to this revenue. Security-wise, biometric verification (facial recognition, fingerprint scanning) has a great contribution to the fraud releases throughout China's intended tokenization technology. The reports reflect that over 90% of users who make their payments in China feel confident regarding biometric authentication;
- The wearables payments' blockchain application in China has converted to a new dimension in enhancing security and creating a more favorable perception for users. It decentralizes authentication, detects fraud in real time, and encrypts transactions, thereby minimizing the chances of hacking. The PBoC has had a connection between Digital Yuan transactions and blockchain, thus producing vast transparency and regulatory advisement;

- According to the research study, WPD has bettered itself in China for financial inclusion purposes because it has accessed some segments of the population that are unbanked or underbanked. Over the last 400 million citizens in China, adopting digital banking services were given access to finance through the catch of wearable devices in urban and semi-urban contexts (World Bank, 2023). China's 'cashless society' model has forced businesses and individuals to use such payment practices, reducing physical banking infrastructure dependence;
- Consumer distrust, high device costs, and cyber security have been some of the challenges faced by the adoption of WPD;
- The study shows that the fintech ecosystem in China develops and implements conditions under which adoption problems are overcome, via:
- Provision of cutting-edge security features such as biometric authentication and blockchain that enhance consumer trust;
- Connection with leading mobile payment platforms like Alipay and WeChat Pay for enhanced accessibility;
- Strategies for financial inclusion that enable WPD to reach a much greater population;
- Thus, using financial technology and innovation in the WPD, the cost of innovation was reduced in cashless transformation in China because many barriers to entry proved effective early to better inclusion financially.

5. Recommendations:

Other countries can benefit from the Chinese experience with wearable payment devices in improving financial inclusion by:

- Enhancing Consumer Trust and Cybersecurity, by supporting Fintech innovations while addressing concerns regarding data privacy and security;
- Providing government financing or making such programs, along with an increase in digital literacy programs, would increase WPD adoption;
- Develop affordable WPD solutions tailored to low-income users.

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