

Chapter 1

Introduction

Background and Significance of Research Problem

Since the turn of the 21st century, intelligent product technology has become a global trend. As a result, smart technology has been introduced to various products like smart phones, smart cameras, smart toilets, and other smart items. This has made the smart home and Internet of Things increasingly popular. In 2015, the Chinese smart home market had an overall size of 124 billion yuan, and analysts predict that the figure will grow to 350 billion yuan by 2020. This indicates that the overall market trend is very positive with ample capital investment, and the global smart home market is rapidly expanding (Li, 2021, pp. 89-102). The smart door lock has now become a popular product in modern society since it offers both convenience and security. It is anticipated that the smart door lock will become the next daily use platform interface of future smart homes, and its market prospects are wide. The smart door lock is an integral part of the smart home industry, with a potential market value of billions of yuan. Furthermore, it is expected that electronic parts and software services will account for 50% of the cost, providing an excellent profit margin.

Door locks as physical attack and defense carriers have been supported by Internet technology, wireless communication technology, password, fingerprint, face recognition, and other technologies for thousands of years, and have now entered the intelligent door lock era. Intelligent door locks first appeared in the 1990s, with the first magnetic card induction electronic locks being used mainly in hotels. Fingerprint locks entered the market in 2000, breaking through the hotel industry and gradually entering the home sector (Li, 2020, pp. 56-67). After more than 30 years of development, smart door locks have become even more intelligent, incorporating B and C recognition, face recognition, iris recognition, finger vein recognition, and APP locks. The smart door lock market has shown good development, the market size of China's smart door lock industry is 21.88 billion yuan in 2021, the market size is expected to rise to 29.9 billion yuan in 2025, in 2022, China's smart door lock market sales of 17.6 million sets, an increase of 3.8% compared with 2021 (RUNTO, 2023).

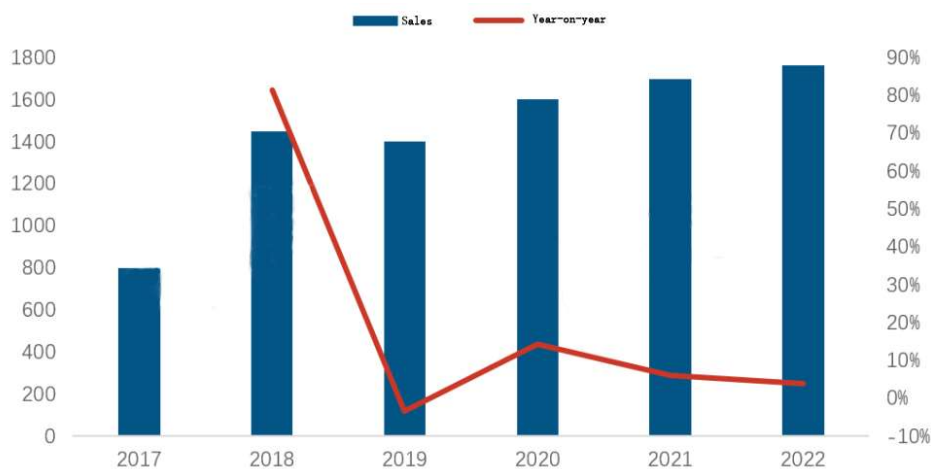


Figure 1.1 China Smart Door Lock Market Sales Size and Change, 2017-2022
(RUNTO, 2023)

The smart door lock is a type of lock that can be controlled intelligently using electronic parts. It is composed of both mechanical and electronic components, with the latter being the primary control center of the lock. The smart door lock is an improved version of the traditional mechanical lock, providing enhanced occupant identification, security protection and intelligent management, resulting in a more advanced, convenient and secure lock.

The physical structure of a typical intelligent door lock includes a front panel (front handle, button/touch panel, card reader, camera, fingerprint or iris module, display module, mechanical keyhole, and front shell of the lock body), a central body (main control board and communication module, voice/buzzer, light bar control board, transmission mechanism, front and rear fixed plates, etc.), and a rear panel (insurance switch, battery compartment cover, rear handle, transmission mechanism, reverse lock knob, and rear shell of the lock body).

The smart door lock uses a combination of identification and control technology (such as biometrics, RFID and password control) and communication technology (such as Wi-Fi, Bluetooth, Zigbee, NB-IoT, and LoRa) in addition to mechanical transmission technology.

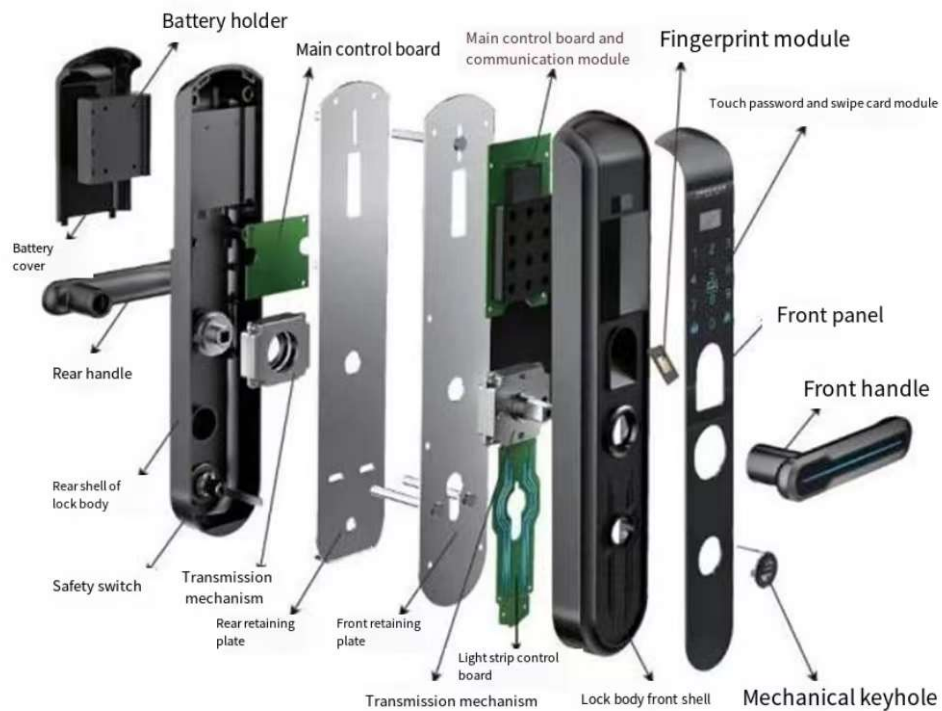


Figure 1.2 Smart door lock physical structure diagram (Tian, 2019, pp. 45-57).

Smart door locks can be divided into four categories: sensing, computing, connectivity, and security, based on their corresponding core technology categories. Sensing refers to how the lock senses external data in various ways, which serves as the basis for the data collected by the smart lock. Computation is the core action of the smart lock, and a powerful microprocessor MCU ensures that the smart lock is driven by the most powerful brain in every decision or operation. Connection is crucial in making smart door locks more intelligent and supporting more functions through network connection technology. Security includes personal and information security, and it is the top concern for most consumers. Deep inside a typical smart lock is a microcontroller as the core, which integrates functional modules such as clock integrated circuits (RTC), power management ICs, voice ICs, motor drive ICs, control panel modules, and fingerprint recognition modules (Tian, 2019, pp. 45-57).

Smart door lock products are characterized by the integration of innovative technologies, emphasis on security and privacy protection, and the ability to respond quickly to market changes. With the continuous expansion of the smart door lock market, competition in the industry has become increasingly fierce. In this situation, how to manage the supply chain, reduce costs, and improve production efficiency has become a problem that smart door lock companies need to think about, so the

supply chain of smart door lock products also needs to respond to these challenges. However, the challenge of responsiveness is exacerbated by the complexity of the components involved in smart door locks, which often require the cooperation of numerous suppliers. Effective communication and coordination between different suppliers is essential to avoid problems such as quality control, delivery delays, or component incompatibility (Lu, 2021, pp. 59-73).

The integration of innovative technologies may face challenges in terms of technical compatibility and integration. Different product specifications and interfaces from different technology suppliers can lead to compatibility issues and require additional engineering adjustments and testing, increasing development costs and time. The pressure to respond quickly to market demands can limit the flexibility of the supply chain. The constant evolution of product features and performance requires the supply chain to quickly acquire the latest technologies and components and to adjust production and supply chain management accordingly. Failure to respond promptly can result in missed market opportunities or inventory backlogs (Li, 2019, pp. 23-35).

The upstream industry chain of smart door locks in China consists of hardware and technology suppliers, of which hardware component suppliers, electronic equipment suppliers, and lock suppliers are foundries. The midstream industry chain involves the production and manufacturing of smart door locks, with foundries and cloud services in the upstream industry providing parts and services for smart door lock manufacturers. The downstream industry chain includes engineering channels, door distribution, distributors, and online e-commerce, all of which are connected to installers (service system). End customers are divided into domestic customers and public customers, both of whom are provided with integrated services (Zhao, 2021, pp. 45-56).

In the supply chain management of smart locks, enterprises face various challenges, including supplier selection and management, inventory management, and logistics. These issues have a direct impact on the efficiency and cost of supply chain management, which, in turn, affects the company's position in market competition. Therefore, reasonable measures should be taken to optimize the supply chain management of smart locks (Li, 2020, pp. 56-67).

Currently, the design and production of mechanical hardware components are relatively complete, and the supply chain is relatively simple and stable. Therefore, research on smart locks mainly focuses on the electronic equipment

supply chain. Through the study of the electronic equipment supply chain of smart locks, it is found that (Zhang, 2019, pp. 67-78):

1) The supply chain is too long, and the lock factory has to procure from many suppliers, which is time-consuming and costly, and quite cumbersome.

2) Electronic equipment manufacturers vary in size and quality, and there is no uniform standard. This situation takes up a large space, and the lock factory incurs high costs for mold opening.

3) Electronic equipment modules are relatively independent, and their security is not good. This fact has implications for the future of high-end Internet of Things software compatibility.

4) The electronic equipment part has a high proportion of the total cost, and the lock factory profits are low. This part mainly includes the smart door lock chip, electronic components, and software services, and it is a vital component of smart locks. Depending on the function, this electrical part of the smart door lock can cost from 20%-40%.

The smart door lock's supply chain is complex, and the products are uneven. Most of them use generic chips that are easy to crack, and they have low-security performance. To solve the problem of the smart door lock supply chain, this study mainly seeks to address the supply chain problems related to the electronic part. This study starts from improving the supply chain management related to the production of smart door lock chips. A new chip, the integrated single-chip security smart door lock chip, is proposed (Chen, 2020, pp. 23-32)

This new chip integrates the original physical independent smart door lock host, security chip, fingerprint identification, touch, Bluetooth, and other functions into a high-security, low-cost single-chip security smart door lock chip. This single-chip security smart door lock chip program not only saves equipment costs, reduces power consumption but also makes the main board PCB board size smaller, leaving more space for door lock product design. The main board module, security module, fingerprint processing module, TSC touch screen, Bluetooth transmission business logic are all integrated into a single chip. This design can not only solve the quality of smart door lock but also reduce hardware costs, improve security control, and shorten the time from design to production of new smart door lock products. This helps smart door lock companies gain an advantage in competition, promotes the widespread use of smart door locks, and provides more technical support to optimize the supply chain of smart door locks. The new smart door lock chip has a strong artificial intelligence recognition capability and fast information processing capability,

which improves the better experience of smart home and makes the development of smart locks have a broader prospect. Thus, the single-chip security smart door lock chip is a feasible solution for optimizing the supply chain of smart door locks (Wang, 2021, pp. 45-52).

The works at the Wenzhou X Chip Research Institute and has discovered that the supply chain involved in smart door locks is extremely complex as it involves many suppliers and results in high cost and time consumption for manufacturers. The electronic device part of smart door locks constitutes a significant part of the production cost, which results in reduced profits for companies in the industry. Furthermore, many smart door lock products are vulnerable to security breaches, which poses a significant concern as the sales of these products continue to increase. Despite these challenges, the researcher believes that there are still potential market prospects for smart door lock chips. As such, the researcher plans to develop an integrated monolithic secure smart door lock SOC chip that utilizes the RISC-V instruction set architecture. The chip aims to address these issues by reducing device costs, improving security control, and optimizing the smart door lock supply chain. The development of this chip is expected to benefit smart door lock companies and consumers alike, as it should result in more efficient and secure products.

Research Objectives

1. To study Smart Door Lock Supply chain management.
2. To study smart door lock supply chain management affecting firm Performance.

Research Hypothesis

- H1. Planning likely affect firm Performance.
- H2. Sourcing likely affect firm Performance.
- H3. Make/Production likely affect firm Performance.
- H4. Deliver likely affect firm Performance.
- H5. Return likely affect firm Performance.

Scope of the Research

1. Scope of the Theory

The purpose of this study is to investigate the impact of smart door lock supply chain management on firm performance. The focus of the study is to provide an in-depth analysis and evaluation of the management practices of various segments of the smart door lock supply chain and their impact on firm performance.

2. Scope of the Population and Sample

The population and sample for the study were collected from the smart lock industry, including manufacturers and general consumers in Wenzhou, Zhejiang Province, China. The sample will be selected through random sampling.

3. Scope of the Location Boundaries

This study was restricted to mainland China.

4. Scope of the Time Limit

The time limit for the study includes the theory and data related to smart door locks in China for the past 10 years.

Research Limitations

This study has limitations as it does not cover all companies and products in the smart door lock industry. Additionally, our exploration of consumer habits and needs is limited to our knowledge of the current market situation and research reports, which may not be comprehensive. Therefore, our research is subject to several limitations and restrictions.

Conceptual Framework

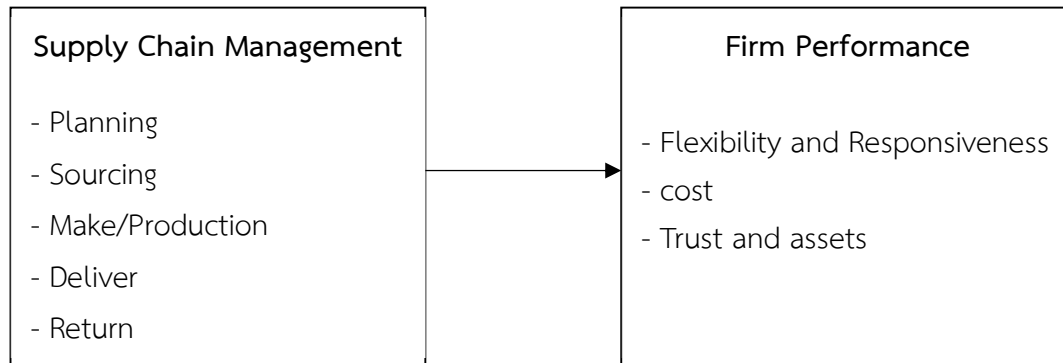


Figure 1.3 Conceptual framework

Definition of Terms

1. Planning: In this study, planning refers to the process of managing the smart door lock supply chain by establishing clear objectives and related strategies to efficiently allocate resources, coordinate activities and forecast demand. The purpose of planning is to achieve smooth supply chain operations at optimal time and cost, to ensure that production meets market demand, and to provide a strategic competitive advantage to the company.

2. Sourcing: Sourcing is the process of selecting, evaluating, and establishing partnerships with appropriate suppliers or supply markets to obtain the required raw materials, components, and services in the smart door lock supply chain management. This includes sourcing decisions, supplier evaluation, contract management, and information sharing and collaboration with suppliers to ensure supply chain stability and product quality.

3. Manufacture/Production: In this study, production refers to the manufacturing process of transforming raw materials and components into final products. It includes production planning, production scheduling, operations control, and quality management to ensure that high-quality smart door lock products are produced on time and on demand, and to optimize production efficiency and resource utilization.

4. Deliver: In smart door lock supply chain management, delivery is the process of getting the final product from the production site to the end user. This includes inventory management, logistics and transportation, supply chain

coordination, and distribution to ensure timely and accurate delivery of products to customers with superior delivery service and customer experience.

5. Return: Return is the process of processing and managing the return of smart door lock products, customer service and post-sales support. This includes activities such as processing return requests, refunds, repairs, and issuing replacements to meet consumers' after-sales needs and maintain good customer relations and brand reputation.

6. Flexibility and responsiveness: In this study, flexibility and responsiveness refers to the adaptability and responsiveness of the smart door lock supply chain management system to change and uncertainty. Flexibility includes aspects of supply chain design flexibility, production flexibility, and delivery flexibility to meet changes in market demand. Responsiveness includes the ability to make quick decisions, operate with agility, and react quickly to meet customer demands and respond to changes in market competition.

7. Cost: In smart door lock supply chain management, cost refers to the various costs and expenses involved in the operation and management of the supply chain. This includes procurement costs, production costs, logistics costs, inventory costs, etc. In this study, cost control is an important objective of supply chain management to reduce operational costs, enhance competitive advantage, and improve company performance.

8. Trust and assets: In smart door lock supply chain management, trust and assets refer to the important factors that build cooperative relationships and shared value among supply chain partners. Trust refers to the mutual trust and cooperation between supply chain partners for effective communication, information sharing and risk.

9. Supply chain management refers to the comprehensive management of minimizing costs, reducing inventories, improving productivity, and enhancing product quality and service by integrating related enterprises such as suppliers, manufacturers, warehouses, and distributors into modern production and service organizations, and coordinating various links through various means such as information flow, logistics, and capital flow to achieve efficient flow of materials, information, and capital. The theory of supply chain management was mainly proposed and developed in the United States, and gradually became an important part of business management in the early 1990s.

10. Process optimization refers to the process of analyzing, summarizing, and improving supply chain processes using the SCOR model to improve the efficiency,

quality, and adaptability of the processes. Process optimization mainly includes process analysis, process reorganization, information system support, etc. By optimizing the process, it makes the business process smoother, more efficient and flexible, thus improving the performance and efficiency of the enterprise, enhancing the core competitiveness of the enterprise and providing a stronger guarantee for the development of the enterprise.

11. Smart door locks are locks that are improved on the basis of differentiation from traditional mechanical locks, and are more intelligent and simpler in terms of user security, identification and manageability. The smart door lock in this study refers to the door lock of the house, hotel, building and other properties, excluding the door lock of the car and other aspects.

The electronic equipment part of the smart door lock is a hardware device consisting of identification and control technology (biometric, RFID, password control, etc.), communication technology (Wi-Fi/Bluetooth/Zigbee/NB-IoT/LoRa, etc.) functions, including the main board, various chips, wires, identification department, etc.

12. New chip for the solution path of the program is to focus on all the functions of the existing smart door lock, design a new chip, that is, integrated single-chip security smart door lock chip, the original physical independent smart door lock host, security chip, fingerprint recognition, touch, Bluetooth and other functions into a high-security, low-cost single-chip security smart door lock chip. With this solution to optimize the supply chain and reduce business costs.

Research Expectation

The people who can benefit from this research report and analysis include the following:

1. Smart door lock manufacturers to simplify the production supply chain of the electronic part of the smart door lock, reduce costs and improve efficiency.

2. Smart Door Lock industry practitioners, who can get to know the current market demand, competition, and feasible supply chain management solutions to make business decisions.

3. Investors and management of smart door lock enterprises: They can learn about the current situation and future trends of the industry, as well as the effectiveness and risks of supply chain management solutions, providing a basis for corporate investment and strategic planning.

4. Users and consumers of smart door lock industry: will be able to use safer and more intelligent products.

5. Smart chip manufacturers: they can learn about the demand of the smart door lock industry and provide direction for enterprise production and R&D.

6. Researchers and scholars: they can learn the current status and hot spots of research in the smart door lock industry, and provide references for further research.

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