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Incentive Machine for Health Data Sharing in Medical Device Supply Chain System Research

Junhua Chen*

Chongqing University of Posts and Telecommunications, China
* Corresponding author: Junhua Chen (Email: 1532041786@qq.com)

Abstract: With the wide application of medical devices in the medical field, health data sharing in the medical device supply chain has become more and more important. Health data sharing can not only improve the efficiency and quality of medical services, but also provide important data support for the R&D, production and use of medical devices, so as to promote the innovation and progress of medical technology. However, due to privacy protection, data security, benefit distribution and other issues, health data sharing in the medical device supply chain is facing a series of challenges. First, privacy protection is the core issue in health data sharing. Patients' health data involves personal privacy. How to ensure that privacy is not disclosed in the process of data sharing is an urgent problem to be solved. Secondly, data security issues can not be ignored. The leakage or misuse of health data may lead to serious consequences, including identity theft, medical fraud, etc. In addition, the distribution of benefits is also an important factor affecting data sharing. In the medical device supply chain, the uneven distribution of interests among the participants (such as medical institutions, medical device manufacturers, data platform operators, etc.) may lead to insufficient enthusiasm for data sharing, thus affecting the collaborative efficiency of the entire supply chain. This study aims to explore the incentive mechanism of health data sharing in the medical device supply chain, in order to promote the realization of data sharing. By constructing an incentive mechanism model for health data sharing, this paper mainly considers the distribution of interests in the supply chain, analyzes the key factors affecting data sharing in the supply chain, and the effectiveness and feasibility of the incentive mechanism.

Keywords: Data sharing, game theory, incentive mechanism, medical device supply chain.

1. Introduction

Since the reform and opening up, China's overall economic level has greatly improved, and people's attention to medical services has gradually shifted from the most basic medical needs to increasingly transparent, convenient, and refined high-quality medical security. The traditional medical model is unable to meet the increasing demand for medical services and quality. With the support of information technology and the integration of various links in the medical system, it has played an important role in improving work efficiency and gradually changed the construction of China's medical system. It pays more attention to the management of the medical process, while also considering high efficiency and medical quality, resulting in the continuous improvement of the level of medical services.

China vigorously promotes the development and application of medical data in policies. The Guiding Opinions of the General Office of the State Council on Promoting and Regulating the Development of Health and Medical Big Data Applications, issued in 2016, mentioned the need to promote the integration, sharing, and openness of government departments' health and medical information technology systems and public health and medical data interconnection, overcome information silos, actively build security standards and norms conducive to the development of health and medical big data, and create a better environment for application development. This indicates that building a sound medical service system cannot be separated from the sharing of health and medical big data. The "14th Five Year Plan for Public Services" released in January 2022 mainly clarifies the active development of smart healthcare in the field of medical digitization, encourages medical institutions to improve their level of informatization and intelligence, and supports the development and application of health and medical big data resources. Enrich commercial health insurance products. Promote mutual recognition of inspection and testing results. At the same time, we will promote the universal application of digital services and the interconnection of service data, and promote the orderly opening of data in public service areas such as healthcare and elderly care, as well as government departments. In May 2022, the "Fourteenth Five Year" National Health Plan issued by the General Office of the State Council proposed to promote the application of universal health information connectivity, implement the standards and norms for the informatization construction of medical and health institutions, rely on physical medical institutions to build Internet hospitals, support medical consortiums to use Internet technology to conveniently carry out services such as appointment diagnosis, two-way referral, telemedicine, and optimize "Internet plus" contracting services. Promote the application of AI, big data, the fifth generation mobile communication (5G), blockchain, the Internet of Things and other emerging information technologies to strengthen national health support and security. The Opinions on Further Improving the Medical and Health Service System issued in March 2023 further reaffirmed the development of "Internet plus+Medical Health", the construction of an industrial Internet platform for the medical field, and the acceleration of the application of the Internet, blockchain, Internet of Things, artificial intelligence, cloud computing, big data, etc. in the medical and health field to strengthen the construction of the health care big data sharing, exchange and security system.

The country also gradually needs to integrate the data generated in the medical system with today's Internet technology, enrich the equipment and devices in the medical

field, and develop applications suitable for doctors and patients, which can more easily solve the medical problems encountered by people in their lives.

At present, the total number of registered Class II and III medical device products within the validity period in China has reached 133901, with 185633 recorded. From 2019 to 2022, the number of product registrations and filings has been increasing year by year, with a total annual growth rate of approximately 36.2%. In 2023, the proportion of domestically produced medical device registered products in China will reach 95.2%. It can be seen that there are a wide variety of medical device products, covering the entire range from disposable consumables to high-end medical equipment. Each product has its specific production, transportation, storage, and sales requirements. The medical device supply chain usually involves multiple links, including production, distribution, retail, etc., as well as multiple participants such as manufacturers, distributors, wholesalers, medical institutions, etc., forming a complex supply chain network. However, due to the isolation of information systems and inconsistent data formats among various links, the flow of information in the supply chain is limited, making it difficult to achieve comprehensive data sharing and integration. There are still some medical device supply chains that use independent information systems and lack effective data sharing mechanisms between these systems. This has resulted in the inability to share patients' medical records, medication records, and other related medical information between different institutions. In this case, patients need to repeatedly fill in the same information in different medical institutions, and even undergo repeated examinations and tests, which not only increases patients' time and money costs, but also increases the waste of medical resources. In the data sharing of the medical device supply chain, a large amount of sensitive information is involved, such as patient privacy, product quality, etc. All parties in the supply chain may be concerned that data sharing may lead to information leakage or security risks; The parties in the supply chain may be competitors who are concerned that sharing data may expose their competitive advantages or trade secrets, and therefore are unwilling to share information with other parties; The lack of effective incentive mechanisms is also one of the reasons why supply chains are unwilling to share data. If there is no clear mechanism for distributing benefits and sharing rewards, all parties in the supply chain may lack the motivation to share data. With the rapid development of science and technology, the strengthening of information construction, and the application of 5G, artificial intelligence, and the Internet of Things, society has entered the era of big data. How to leverage 5G, the Internet of Things, and big data to improve the efficiency of medical services and the medical experience of the people has become an important concern in current society. Its core is to promote medical data sharing through the use of medical informatization, in order to solve current medical problems.

Currently, whether in China or abroad, data sharing technology has been applied in various aspects of the medical field, including "big data for disease treatment", "telemedicine", and so on. All of these indicate that the next direction in the medical field is smart healthcare, and to achieve this, data sharing is needed. Patients, hospitals, medical device manufacturing companies, and others need to fully cooperate and share data to carry out this project.

With the rapid development of medical information digitization in China, the digital systems of major medical institutions store massive amounts of medical information. These medical data have significant utilization and analytical value for healthcare professionals. Therefore, if technologies such as big data mining are used to analyze, develop, and utilize massive medical information data in a reasonable manner, and the medical information is parsed and provided to doctors, patients, and users of big data mining, it can help patients conduct preliminary self diagnosis, reduce the pressure on doctors, improve the efficiency of hospital medical practice, and reduce the difficulty of patients finding suitable doctors. Based on the challenges faced by the healthcare system, data sharing can play its role. By integrating, sharing, and mining medical information, it can achieve good improvements in patient convenience, treatment time, treatment costs, big data analysis, medical insurance payment decisions, and other aspects. However, due to regional economic disparities, there is still a long way to go for medical data sharing in the current healthcare system. Therefore, it is of great significance to draw on the good practices of the healthcare system in sharing information to promote medical data sharing.

2. Analysis of Medical Device Supply Chain System

2.1. Development Status of Medical Device Supply Chain

2.1.1. Current Status of Medical Device Development

Medical devices refer to instruments, equipment, tools, in vitro diagnostic reagents and calibrators, materials, and other similar or related items directly or indirectly used for the human body, including the required computer software. Medical devices include medical equipment and medical consumables. Utility is mainly obtained through physical means, not through pharmacology, immunology, or metabolism, or although these methods are involved, they only play an auxiliary role. The purpose is to diagnose, prevent, monitor, treat or alleviate diseases; Diagnosis, monitoring, treatment, alleviation, or functional compensation of injuries; The examination, substitution, regulation, or support of physiological structures or processes; Support or maintenance of life; Pregnancy control; To provide information for medical or diagnostic purposes by examining samples from the human body.

(1) Development History

In the past decade, the technological progress of medical devices has been particularly significant. Especially after 2010, China's medical device industry entered a new stage of intelligence and informatization. The application of technologies such as artificial intelligence, the Internet of Things, and big data has gradually made intelligent medical devices the main direction of the industry. For example, new technological products such as medical imaging diagnostic equipment and intelligent monitoring devices based on big data analysis are driving the medical device industry into a new stage of development. In addition, the quality and performance of domestic medical devices have also been significantly improved, greatly enhancing the competitiveness of domestic enterprises in the global market.

The rapid development of the medical device industry also benefits from sustained policy support. In recent years, the "Healthy China 2030" strategy and healthcare system reform

have continuously promoted the localization process of medical devices. The government encourages medical device companies to strengthen independent innovation and accelerate the localization of high-end medical devices, especially in high-end fields such as imaging equipment, life support equipment, and surgical instruments. Policy support provides a favorable development environment for domestic enterprises. At the same time, the country has gradually standardized the market order and improved the standardization and normalization level of the industry by establishing a medical device registration and certification system.

(2) The market size of the medical device industry is gradually increasing, but the growth rate has declined

With the improvement of residents' living standards and health awareness, as well as the improvement of medical insurance policies, the development space of China's medical device industry is huge, and the market size is gradually increasing. According to the statistics of the Medical Device Supply Chain Branch of China IoT, the market size of China's medical device industry increased from 623.75 billion yuan to 1180 billion yuan from 2019 to 2023, with the growth rate decreasing from 17.60% to 10.04%, as shown in Figure 1.

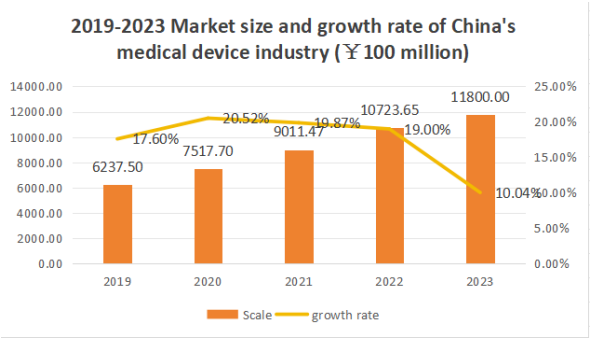

Figure 1. Market size and growth rate of China's medical device industry

2.1.2. Health Data Circulation and Challenges in Medical Device Supply Chain

(1) Data integration requirements of medical institutions

The construction of data systems in domestic medical institutions mostly comes from different suppliers, using different information standards and different data formats. Information and resources cannot be shared among various modules of the hospital. The medical management system, laboratory testing system, medical imaging system, clinical information system, drug management system and other systems still have many information islands within the hospital. Not only does the integration of hospital information need an effective method to achieve safe, efficient and flexible data exchange and sharing, but also a standard and shared hospital information platform support should be established. The medical institution data platform is an information hub (ESB) that supports the integration and integration of hospital clinical business systems, supports information sharing and interaction between different business areas within the hospital, and realizes business collaboration between different areas through service integration.

(2) Collaborative needs of clinical business services

Medical institutions are complex business and management systems based on the provision of medical services, which include complex business relationships from clinical services, medical support management to operation management. For example, between the appointment and registration of patients and clinical treatment, between outpatient and emergency services and inpatient services, between the issuance of doctor's orders and the implementation of nurse's orders, between the application of doctor's examination and inspection and the business of inspection and inspection departments, between the doctor's diagnosis and treatment business and pharmacy, drug storehouse, as well as between the different steps of the transfer and clinical path between departments, between diagnosis and treatment and settlement business, between medical services and management business, etc. The use of consistent service access can effectively reduce the complexity of service access, optimize the management of services, realize the service arrangement and business process management based on business rules, and realize the business collaboration between different fields.

(3) Group and regional medical development needs

By connecting with the regional national health information platform, the medical institution data platform can realize the information sharing and interconnection between the hospital and the administrative department, and then realize the business collaboration of health information interconnection with other medical and health institutions in the region. Such as hierarchical diagnosis and treatment, two-way referral, mutual recognition of inspection suggestions, regional remote consultation, regional auxiliary medical treatment and regional medical public service. The construction of the platform has accumulated high-quality and effective data for the hospital, realized the information interaction and collaboration of different businesses in the hospital, and also provided the necessary basis for cross agency data sharing. The establishment of electronic medical record data resource center based on the platform can further provide general, efficient and high-value value-added extended applications for hospitals.

However, due to the imbalance of regional development level and data security problems, it is difficult for medical institutions to build a cross agency data sharing platform, mainly involving the cost and data security of the data sharing platform. Mindray medical signed a strategic cooperation agreement with Kunming Third People's hospital to carry out discipline construction and talent training services for the hospital by integrating high-quality resources at home and abroad for infectious diseases, assist the hospital to improve its operation and management ability and build differentiated competitiveness and industry influence. In the current process of deepening the reform of the medical system, the two sides complement each other's advantages to achieve strategic sustainable development.

2.2. Medical Device Supply Chain Mode

2.2.1. Traditional Mode

The dealer mode is the main mode in the medical supply chain. The dealer mode can be roughly divided into commission mode (high open mode) or channel mode (low open mode or high open high return mode).

In the Commission mode, there is only one single distributor. The manufacturer sells the products to the distributor at a higher ex factory price. The distributor charges a certain proportion of commission according to the distribution services provided. The marketing promotion is

organized by the manufacturer or outsourced to other third parties.

Under the channel mode, there are generally multi-level distributors. The R&D and production are undertaken by the manufacturer. The marketing, promotion, logistics and services are undertaken by distributors at all levels (large contractors, provincial, municipal, county and small contractors). Distributors at different levels assume different roles and functions. The distributors at all levels also undertake other functions such as goods delivery, ticket delivery, and advance payment. The manufacturer reduces the ex factory price and sales expenses of products, and the difference is deferred to subsequent dealers at all levels. Under this mode, the manufacturer can maintain relatively low working capital, maintain low deposit regulations, bear low tax costs, and maintain high compliance,

In the medical device industry, the channel mode (low opening mode) through multi-level dealers is the mainstream mode, as shown in Figure 2.

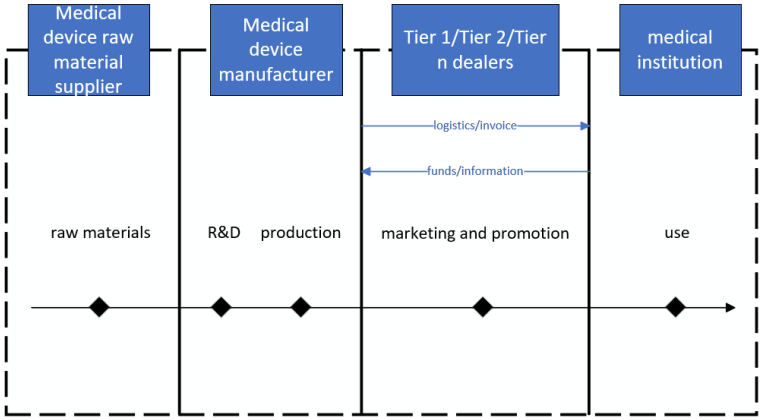

Figure 2. Traditional supply chain of medical devices

In the current mode, due to the many and opaque sales links of products, dealers and medical representatives at all levels participate in the distribution of sales profits as a link of the supply chain, which to some extent leads to the false high price of products.

2.2.2. Mode after Medical Reform

"Two ticket system" means that medical production enterprises issue one-time purchase and sales invoices to circulation enterprises, and circulation enterprises issue one-time purchase and sales invoices to public medical institutions. The main ways to meet the requirements of the "two vote system" are enterprise direct selling mode ("one vote system") and commission mode (high opening mode).

In the direct selling mode, manufacturers establish their own business teams, build sales networks, and integrate manufacturers. Manufacturers can achieve this through two ways: one is the acquisition and integration of existing dealers; the other is the establishment of their own business team, including the establishment and incorporation of existing dealers' personnel from zero. Under this mode, enterprises can not only carry out marketing promotion by themselves, but also consider using external suppliers at the same time.

Under the Commission mode, the manufacturer undertakes R&D and production, and the subsequent distribution and logistics are entrusted to large commercial circulation enterprises. Enterprises can not only carry out marketing promotion by themselves, but also consider using external suppliers at the same time. Some of the original dealers can be transformed into service providers (various consulting companies, advertising companies, CSOs, logistics service providers, pre-sales, in-sales and after-sales service providers, etc.).

Public medical institutions in pilot provinces (districts and cities) of comprehensive medical reform and pilot cities of public hospital reform will conduct "two vote" procurement.

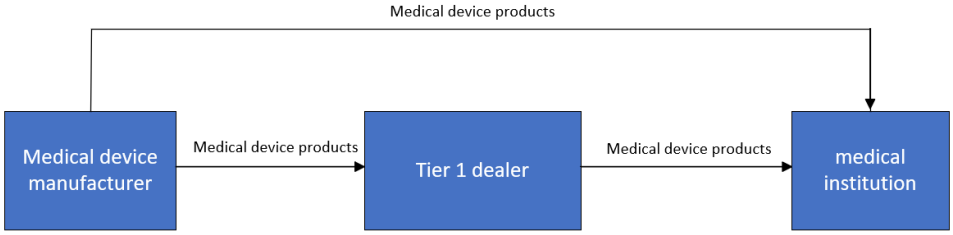

Figure 3. Medical device supply chain after medical reform

At present, the outstanding medical device manufacturers and medical device retailers in China's pharmaceutical industry now rely on customers in the sales process. In order to provide better services to customers, medical device manufacturers should seize the opportunity of the new retail and relevant national policies, reposition their own development, change the profit model, and improve their business.

2.3. Analysis on The Main Body Relationship of Medical Device Supply Chain

The structure of China's medical device supply chain is complex, including raw material supply enterprises, manufacturing enterprises, circulation enterprises, sales enterprises (medical institutions, retail pharmacies), patients (consumers) and many other supply chain entities. There are

many subjects involved in the medical device supply chain, but the most contact with the public is the sales end, which is closely related to people's lives. Therefore, people are more concerned about whether the quality of the products purchased in the sales end is qualified and whether the product functions are effective. Therefore, this paper mainly studies the medical device supply chain in the sales part, involving medical device manufacturers, medical institutions and consumers. The supply chain structure is shown in Figure 4.

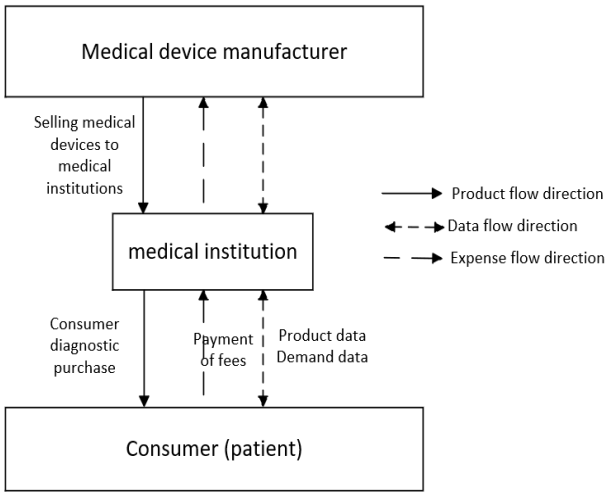

Figure 4. Medical device supply chain structure

The specific analysis of each subject is as follows:

① Medical device manufacturer

Pharmaceutical manufacturers are at the source of the medical device supply chain defined in this paper, and their downstream supply chain members include medical institutions and consumers. The main role of medical device manufacturers in the medical device supply chain includes two points: one is to produce and sell medical devices according to market information; Second, cooperate with medical institutions to update and upgrade medical device products using health data. Generally speaking, pharmaceutical manufacturers first collect and sort out market demand information, and then make "health" plans. After the production of medical devices, they will deliver them to retailers or consumers through the logistics system.

② Medical institutions

The medical institutions in the medical device supply chain defined in this paper mainly refer to hospitals and community clinics. Medical institutions are one of the main channels connecting medical device manufacturers and consumers. The role of medical institutions in the medical device supply chain is to purchase medical devices from medical device manufacturers and provide consumers with corresponding medical devices according to the diagnosis of the disease.

③ Consumer (patient)

Patients are the end consumers in the medical device supply chain. As medical devices are related to people's life safety, consumers are in a passive position and cannot give up buying because of the high price. However, with the deepening of medical reform, people's requirements for health are getting higher and higher, and consumers are also paying more and more attention to product quality and function.

Therefore, the relationship between the subjects is that the nodes in the medical device supply chain are closely related. Medical device manufacturers produce medical devices according to consumer demand and market information, which provides a material basis for the circulation of medical devices. At the same time, they sell medical devices to medical institutions. This process is the key to the value-added of medical devices. Finally, consumers buy medical devices according to the diagnosis after seeing a doctor.

3. Literature References

3.1. The Medical Equipment Supply Chain

The medical equipment supply chain is a very important component of the medical system. By 2022, the operating revenue of medical equipment manufacturing enterprises in China will reach 1.3 trillion yuan, and it will continue to increase year by year. The combination of modern Internet technology with medical equipment is crucial to the development and innovation of medical equipment in China.

In existing literature, the focus is mainly on management direction. Yang Fanfan[1] analyzed the problems in the current management mode of medical consumables, based on SPD, and introduced in detail the establishment and implementation process of the medical consumables SPD supply chain mode in combination with the actual situation of the hospital. At the same time, he analyzed the implementation effect of the medical consumables SPD supply chain mode according to the actual situation of our hospital. Zhang Yanfang[2,3] focuses on the regulatory strength of medical devices. After analyzing the successful application of the "Yijie Cloud" comprehensive supply chain management platform, it is believed that practical and effective measures should be taken from three aspects: government, enterprises, and cloud platforms to accelerate the application of SaaS cloud platforms in medical device supply chain management, in order to promote the development of industry informatization, systematization, and modernization. The development direction and trend of medical material supply chain management have become an indispensable part of the medical industry with the continuous development of medical technology and the increase in medical demand. The development direction and trend of medical supplies supply chain management will become more digitized and intelligent, bringing new opportunities and challenges that require strengthening management and innovation from all aspects. Shi Haifeng introduced UDI coding into medical equipment, designed a traceability supervision system for medical equipment product supply chain, and constructed traceability of medical equipment supply chain. Wu Xiaoli[4] and others are based on the Unique Device Identifier (UDI) for medical devices. Research the application of UDI in daily business management and inventory management at all levels, providing reference for achieving full lifecycle management and full process traceability of medical devices. Geng Jing[5] et al. utilized the supply chain synergy effect generated in the medical device management of Fudan University Affiliated Pediatric Hospital, and established a medical device supplier management platform based on the cloud platform service model using information technology and workflow as the engine. They integrated and shared hospital resources with the supplier relationship management platform. Cui Zhongfu[6] has entered a golden development period in the medical equipment industry. Combining the existing problems and the development of Internet technology in

today's society, he puts forward five suggestions: standardization helps the standardized development of the industry, scale boosts the reshaping of the industry pattern, integration strengthens supply chain management services, specialization promotes the upgrading of the industry, and digital intelligence enables high-quality development. Jiang Min[7] has integrated medical device supply chain and IoT technology, improved the operation status of capital flow, information flow, and technology flow in the supply mode, and analyzed the current situation and existing problems of IoT application in the medical device supply chain of grassroots hospitals. Targeted innovative measures have been proposed.

In the research on the medical device supply chain, scholars mainly focus on the management direction of the supply chain and propose a series of solutions to the existing problems. The application of information technology in the supply chain mainly involves tracing product information during the circulation process and after use, without involving the process of manufacturing products after transmitting user diagnostic data to medical device manufacturers.

3.2. Data Sharing

(1) Combining blockchain technology

To ensure the security of data sharing, many scholars have combined data sharing with blockchain technology to ensure the correctness, security, and privacy of data. Liang Rujin[8] et al. designed a system based on blockchain smart contracts to achieve distributed data storage through the Inter Planetary File System (IPFS) in order to solve the problems of single point of failure, single point attack, and inflexible access control caused by traditional data sharing models where data is stored in the center and permissions are centralized in the center. Zhang[9] proposed that sharing the inventory status of suppliers can help improve the coordination ability in the two-tier assembly system, thereby making the production process more efficient. Liu[10] et al. studied the impact of information leakage in supply chains under different contract structures. Their equilibrium results highlight the efficiency reduction caused by information leakage. Bimpikis[11] studied how information quality plays an important role in data sharing. Zaerens[12] pointed out in his research that smart contracts can be used to monitor the information quality and transaction balance among participants in the military supply procurement environment. Zhang Lihua[13] et al. designed a secure data sharing scheme for microgrids, which improved the traditional Proof of Stake (POS) consensus mechanism by addressing the issue of forking. However, the improved consensus mechanism cannot meet the consensus requirements in large-scale node application scenarios. Huang Zhengzheng[14] et al. proposed a knowledge sharing model based on consortium blockchain technology, which achieves reliable storage of knowledge data through IPFS system and uses smart contracts to ensure data security. However, the design of using smart contracts to implement the entire knowledge sharing process results in excessive system overhead and cannot be applied to large-scale data management . Zhang Lei[15] et al. proposed a patient controllable and cloud chain collaborative medical record sharing model. By using clustering algorithms to improve the practical Byzantine consensus algorithm in medical record sharing, the algorithm efficiency was improved to a certain extent, but the algorithm's fault tolerance needs to be improved. Tao Yongcai[16] et al. proposed a blockchain based data sharing model for the Internet of Vehicles, which can ensure the privacy and security of on chain data. This solution chooses vehicles as nodes, but most vehicle nodes have weak computing power, which leads to low consensus efficiency. Manu[17] et al.'s blockchain based data management platform enables reliable data collection and secure sharing, promoting data exchange between different intelligent manufacturing platforms and enhancing the overall value of the system. Razzaq[18] et al. proposed an open IoT data sharing framework that supports blockchain, providing technical reference for solving the problem of low autonomy and enthusiasm in data sharing among manufacturing enterprises. Wang Shaohua[19] et al. focused on the food industry and proposed a threshold proxy re encryption privacy data sharing method for pre packaged food traceability. This method aims to securely share private data such as recipes and secret recipes while tracing, enabling better collaborative production in the supply chain. Yang Yanbo[20] stores big data in a public distributed storage hash table and uses blockchain to address trust issues in data storage, access, and user revocation. Implementing signature and authentication for blockchain transactions based on an uncertified cryptographic system, while blockchain provides public key broadcasting for IoT devices, thus overcoming the shortcomings of uncertified cryptographic systems. Truongnb[21] implements transparent social network data sharing based on Fabric.

Related research has shown that blockchain can provide comprehensive support for data sharing, from processes to protocols to platforms. However, data sharing will also bring certain risks of privacy leakage, especially in the transparent sharing mechanism built on blockchain. Privacy protection will also become an important part of whether data sharing can ultimately be implemented.

(2) Construction and guarantee of data sharing

In the production and operation of enterprises, a large amount of data is generated, which leads to increasingly frequent data sharing. As a result, there are issues such as how to build a data sharing platform, promote the sustainable development of data sharing, and protect data security.

Many scholars at home and abroad have conducted research on this series of problems in order to find better methods to solve them. Jiang Yuhao[22] achieves open sharing of data elements through public data traction, providing dynamic protection for different entities, cultivating emerging market entities, and enhancing the richness and flexibility of market behavior. Wang Lei's[23] research takes the construction process of the Shanghai Public Data Platform as an example to analyze the operation process and mechanism of public data sharing in accelerating the digital transformation of mega city governance. Zhang Huijuan[24] takes the Russell Group of universities in the UK as the research object, conducts website research to sort out the research data sharing practices and effects of its member universities, summarizes its service characteristics, formulates data sharing service policies, promotes collaboration among internal departments, and improves the data sharing ability of researchers. Baars[25] et al. conducted further research on data sharing and proposed collaborative methods for data sharing and analysis in intelligent manufacturing ecosystems, as well as the concept of data cooperatives. Sheng Xiaoping[26] et al. conducted a literature search both domestically and internationally to investigate the significant impact of multiple factors on data sharing. Wang

Qian[27] et al. designed three sharing strategies for data sharing using evolutionary game theory. Sheng Zhiyun[28] et al. studied the data sharing problem between platform owners and participating enterprises in three consecutive scenarios, which is beneficial for promoting data sharing between platform owners and participating enterprises and providing guidance for promoting data creation value. Yang Shaocheng[29] et al. proposed an encryption scheme based on ciphertext attributes to address the privacy leakage issue in the data sharing process of fleet vehicles in the Vehicle Social Network (VSN). It can effectively prevent privacy leakage during the data sharing process of fleet vehicles, and construct an access tree to design access policies to solve the problems of high time overhead and low data sharing efficiency. Li Xianfeng[30] introduced data lake technology to address the inconvenience of sharing applications caused by scattered data storage in provincial-level satellite direct receiving stations. The data is centrally managed in the lake and unified data sharing services are provided. Liang Rujin[8] uses a hybrid approach of consortium chain and private chain to protect data from illegal tampering by leveraging the immutable nature of blockchain; Through on chain smart contracts, flexible data sharing and controllable access can be achieved, with transparent and traceable access records, solving the problem of traditional data centers being unable to regulate malicious behaviors such as illegal authorization. Cao Laicheng[31] proposed a dynamic game oriented k-anonymity privacy protected data sharing (KPDSDG) scheme to address issues such as a lack of labeled training data and data privacy leakage when training deep learning models. The optimal data k-anonymity scheme was designed by introducing dynamic game strategy to protect data privacy and secure sharing. A data anonymization evaluation framework has been proposed to further improve data privacy and availability, and reduce risks. Finally, a conditional generative adversarial network is used to generate data and solve the problem of labeled samples. This scheme simultaneously satisfies data anonymity, data augmentation, and data security sharing. Wang Zheng[32] et al. proposed an attribute based, cleanable, and collaborative data sharing scheme to address the growing inability of traditional CP-ABE solutions to meet the needs of data sharing in terms of access policy expression and ciphertext security in the context of new medical IoT scenarios. The ciphertext purification mechanism effectively addresses the threat of malicious data owners.

In terms of data sharing, most scholars have introduced blockchain, which can effectively ensure the security of data. Other scholars consider specific application scenarios and design a data sharing scheme to ensure secure storage and application of data. But few scholars have combined data sharing with the analysis of the medical device supply chain.

3.3. Incentive Mechanism

In the supply chain, there are issues such as information asymmetry, strong market uncertainty, and fragile cooperation relationships between supply chain enterprises. Establishing effective incentive mechanisms is beneficial for addressing relevant unfavorable factors and is of great significance for maintaining and developing cooperative relationships between supply chain enterprises.

Zheng Qiu[33] qing and others studied community group buying platforms and proposed an incentive mechanism of "cost sharing+benefit sharing" to overcome the information asymmetry in the level of preservation efforts. This mechanism incentivizes suppliers and team leaders to share information more openly, helping to promote the sustainable and stable development of the community group buying supply chain. Zhang Xumei[34] et al. studied a supply chain consisting of third-party shared manufacturing platforms, productive service providers, and multiple manufacturers purchasing productive services. They adopted a quality information disclosure incentive method based on two compensation contracts, which adopted different incentive situations according to the level of information disclosure, and finally used the two compensation contracts to incentivize each situation. Guo Sandang[35] and others established a manufacturer led closed-loop supply chain, studied the amount of recycling subsidies, their impact on product prices and wholesale prices, recycling rates, and profits of all participants in the closed-loop supply chain. Yan Yan chao[36] et al. found through their research on online sales recycling models that the optimal profits of manufacturers and service providers are influenced by the positive and negative profit sharing ratios. Wang Yuyan[37] et al. constructed a closed-loop supply chain for e-commerce under financial constraints, and proposed that e-commerce platforms simultaneously adopt two strategies: sharing the cost of recycling services with remanufacturers and obtaining bank loans, which is the optimal choice to relieve financial constraints. You Tianhui[38] et al. studied the impact of recycling transfer prices and loan interest rates on the optimal strategy of closed-loop supply chains. Liu[39] et al. designed an incentive mechanism with transfer payments, and research has shown that high freshness elasticity and high demand signal accuracy make the incentive mechanism easier to implement. Zhang[40] et al. studied the motivation behind information sharing between cross-border e-commerce enterprises and overseas manufacturers, and demonstrated that appropriate incentive mechanisms can achieve a win-win situation. Zhang Honghong[41] introduced financial institutions and fresh fruits, combining basic rewards with incentive rewards calculated based on the performance of logistics regulatory enterprises in fulfilling regulatory responsibilities. And verified through real-life cases. Cao Yu[42] et al. explored the optimal level of preservation effort under different decision-making modes, and studied the impact of different modes of cost sharing contracts provided by retailers themselves and cost contract formulation by suppliers and retailers on the overall insurance effort level of the supply chain.

Scholars have already conducted mature research on incentive mechanisms, and many literature have applied incentive mechanisms in the medical device supply chain, mainly constructing game models from the perspectives of cost and benefit.

4. Conclusion

Given the importance of the medical device market and the crucial role of data sharing in its development, this article establishes a medical device supply chain model that considers data sharing from the perspective of the medical device supply chain, based on game theory, optimization theory, and supply chain management theory. The study examines the differences between pricing and revenue in the basic and platform models of the medical device supply chain, and provides incentives for building a data sharing platform for the medical device supply chain. The study explores the impact of different incentive models on pricing and revenue

in the medical device supply chain, providing theoretical solutions for the current data sharing problems in China's medical device supply chain. The main conclusions drawn from this article are as follows:

(1) Comparing the medical device supply chain under the basic model and the data sharing platform model, the platform model has better pricing and revenue than the basic model. It can be seen that data sharing in the supply chain can drive the overall supply chain to develop in a more favorable direction.

(2) In the cooperation between medical institutions and manufacturers, for medical institutions, manufacturers share the cost of services, the service cost model and the manufacturer's service subsidy model can incentivize professional pharmacies to improve their services under certain conditions effort level. Especially when the efficiency of medical device supply chain services is low, the service subsidy model will provide greater incentives for medical institutions to provide patient services. However, due to the inefficiency of professional pharmacy services at this time, it will have a negative impact on the entire medical device supply chain.

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