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# Customization and Performance of Service-Oriented Manufacturing Information System: The Mediating Effect of Information System Flexibility

**Peng Niu**

School of Business Administration, South China University of Technology, Guangzhou, China
Email: bmniupeng@mail.scut.edu.cn

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## Abstract

The purpose of this paper is to provide empirical evidence for the validity of the relationship between service-oriented manufacturing information system (SMIS) customization and performance from three aspects: data flexibility, process flexibility and system flexibility. We select some questionnaires from the third round of High-performance manufacturing (HPM) data to construct the construct, verify the reliability and validity of the construct, extract principal components, and analyze the mediating effect by using multiple chain linear regression and structural equation model. The results show that SMIS customization has a significant impact on its performance, and this effect works through its flexibility. More specifically, it is the multiple chain mediation effect composed of data flexibility, process flexibility and system flexibility. The importance of SMIS customization and flexibility to the organization is made clear, which helps practitioners understand the internal mechanism that affects SMIS performance, so as to use limited resources to improve system performance.

## Keywords

Service-Oriented Manufacturing Information System, Customized Information System, Flexibility of Information System, Information System Performance, Mediating Effect

## 1. Introduction

"Industry 4.0" made it possible for a new intelligent manufacturing (IM) mode to become the mainstream of the world manufacturing industry. This new model is equipped with information technology, sensors, advanced equipment, industrial chain and service chain, which is highly flexible and effective, which can work independently and interact with the production environment. Professor Sun [1] pointed out that Service-oriented Manufacturing (SOM) is to achieve highly collaborative, innovative, flexible and efficient distribution and its core competitiveness through the integration of products and services, the integration of IT/IS, the whole process of customer participation and the mutual provision of production services and service production by enterprises. With the emergence of new technologies such as cloud computing, Internet of Things (IOT), big data, artificial intelligence(AI), digital factory and "5G+ Industrial Internet", many changes and new development directions of manufacturing industry have been triggered [2] [3] [4]. IM integrates the data of design, production, warehousing and logistics in the manufacturing process by means of digitalization and informationization, and optimizes the business process, production process and service process by relying on the changes of real-time data flow, thus assisting decision-making and realizing the optimal allocation of resources. The technical core of "China's intellectual manufacturing" is information technology, which is applied information technology to all links of industrial production by means of deep integration of industrialization and informationization (IOII), so as to change the traditional industrial production mode. As a big industrial country in the world with a large scale of equipment manufacturing industry, China has its own advantages [5]. With the largest number of researchers in the world, China has great potential for developing resources. The speed and quality of manufacturing in China are excellent. Smart factories can produce a customized refrigerator every 10 seconds and a car every 105 seconds. During the 2019-nCoV epidemic in 2020, China produced 60% of the world's masks, with a daily output of 1 billion, and a daily output of 700,000 medical protective clothing. According to the statistics of our institute, as of the beginning of 2019, the total number of enterprises participating in the IOII reached 1,419,571. However, the intelligent manufacturing capability of most equipment manufacturing enterprises in China is still weak [6], the transformation to intelligence is still in the initial stage. Therefore, it is very important to help Chinese manufacturing enterprises carry out intelligent transformation and upgrading, and to grasp the internal relationship between information system customization and performance in the process of IOII.

Most of the existing literatures focus on information system, which studies its influencing factors and its impact on organizational environment. A few literatures focus on SMIS, which mainly studies its evolution, index system and its impact on the environment. Few scholars pay attention to the influencing factors of SMIS (detailed introduction in the second section). Different from traditional information systems, SMIS emphasizes the full participation of customers and the high coordination between upstream and downstream of the supply chain. Therefore, we believe that the factors affecting SMIS performance may be different, and the influencing ways may be more diverse and complex. Referring to the relevant literature and the research data of IOII in the Pearl River Delta region of China, we use empirical methods to analyze the relationship between SMIS customization, flexibility and performance, in order to clarify the internal influence path and provide theoretical support for related research.

The research structure of this paper is as follows: Section 2, combing concepts and related literature. In the third section, under the guidance of literature review, we try to establish a conceptual model and put forward relevant assumptions. Section 4, analyze the questionnaire and data. Section 5, verify the validity of the hypothesis and give the analysis results. Section 6 and Section 7 are the discussion and conclusion respectively.

## 2. Concepts and Literatures

### 2.1. Service-Oriented Manufacturing Information System

SOM is a new business model, a new production organization model and a new manufacturing model. Emphasis additional value-added services to help manufacturing enterprises get rid of the homogenization of product competition, and at the same time strive to develop their own core business and provide users with integrated overall solutions. Collaborative manufacturing and value innovation have brought fundamental changes in product service system, marketing mode and operation mode. SMIS is the cornerstone of SOM's efficient and stable operation, which can be defined as the integration of productive services (such as customers participating in the whole process, logistics and finance) and service production (spare parts, raw materials and assembly manufacturing) in the whole manufacturing service chain. SMIS software consists of several independent and interrelated information systems, such as enterprise resource planning (ERP), manufacturing execution system (MES), customer relationship management (CRM), finance and customs, etc. All information systems are dynamically interconnected to form a temporary benefit cooperation contract [7].

Compared with the traditional manufacturing information system based on leading enterprises, the main characteristics of SMIS are open, far from equilibrium and nonlinear interaction. Scholars often analyze from the perspective of complex systems, and think that SMIS is a dynamically coupled and unstructured system, which has changed from a relatively unified and structurally stable simple system to a dynamically evolving system. Change from established process and static structure to dynamic reorganization and uncertainty to meet customer needs. In terms of performance, SMIS mainly starts from the basic requirements of security, accuracy and reliability, and ensures new requirements such as robustness, dynamic reconfiguration and dynamic adaptability. Highly customized requires highly dynamic adaptation of SMIS. Therefore, customizing SMIS is an important guarantee and prerequisite for the successful promotion of service-oriented manufacturing mode, and it is necessary to describe the relationship between SMIS customization and performance from a new perspective.

## 2.2. Customization Degree of Information System

There is no invariable or universally applicable information system, which should closely fit the actual management of enterprises. To what extent enterprises develop, they should have corresponding information level to adapt to business needs and management changes. When the company's products and business processes are complex, or the company has its own management philosophy, lofty ideals and advanced strategic planning, the organization will meet the actual production needs of enterprises through customized information systems [8] [9] [10]. In other words, managers hope to improve their work efficiency and save costs through informationization and industrial intelligentization.

SMIS customization integrates enterprises, customers, suppliers, employees and environment. Under the guidance of systematic thought, with the viewpoint of overall optimization, a set of information system suitable for manufacturing enterprises is developed, which is supported by standard technology, modern design method, information technology and advanced manufacturing technology. The ultimate goal is to support productive service and service production with low cost, high quality and high efficiency [7] [11]. SMIS customization inherently includes system integration. Internal integration means that "manufacturers build their own organizational strategies, practices and processes into collaborative and synchronous processes to meet customer needs". External integration means that "the manufacturer cooperates with its external partners to build the inter-organizational strategy, practice and process into a collaborative and synchronous process" [12] [13].

"Made in China 2025" has promoted the transformation and upgrading of manufacturing enterprises to service-oriented manufacturing like a new bamboo shoot in spring. Information system customization is also widely used and well applied in various manufacturing industries such as automobile, elevator and other machinery manufacturing, military heavy industry manufacturing, abrasive tools manufacturing, assembly line equipment manufacturing, electronic equipment manufacturing, electrical industry, furniture manufacturing and even garment manufacturing [14] [15] [16] [17]. As mentioned in the introduction, the SMIS supports customers to participate in the whole process and provides added value for stakeholders in the manufacturing value chain. Obviously, SMIS needs to adapt to the market environment, customer demand, enterprise status and enterprise development strategy from beginning to end. Customization is the adaptive behavior of the system between service process, production process and information system components, which can make the information system more suitable and more in line with the existing activities and business development of enterprises. Good customized SMIS can improve office efficiency, production efficiency, design efficiency, delivery efficiency, etc., save storage cost, logistics cost, production cost, operation cost, etc., improve information system performance, and finally improve the comprehensive competitiveness of enterprises, and win a place in the global manufacturing field.

### 2.3. Flexibility of SMIS

Scholars have done a lot of research on the flexibility of information systems, and the concept of flexibility is usually regarded as a vague term with many different meanings. Flexibility is closely related to terms such as adaptability, agility, robustness, versatility, elasticity, robustness and extensibility [18] [19] [20] [21]. It can be understood as the degree to which an information system can be modified or upgraded in the subsequent life cycle [18]; the ability to maintain its function and performance under the influence of uncertain factors such as attacks in daily operation [19]; the ability to still support operations when business changes, demand changes or strategy changes [20]. In a rapidly changing and highly competitive market environment, enterprise decision-makers will choose and determine information system strategies according to internal and external environment, combined with their own business needs and resource conditions, and build flexible information systems gradually to improve the operational efficiency of enterprises and reduce operating costs [22] [23] [24]. The flexible process of information system includes several steps such as business process analysis, data flow design and system function setting. From the perspective of information system practice, the flexibility of information system mainly includes three parts: data flexibility, process flexibility and system flexibility, which run through the whole process of information system project [23] [25] [26].

Generally speaking, the good performance of SMIS depends on the normalization of basic data, the institutionalization of business processes and the integration of management systems. The rational integration of information systems in SOM enterprises can enable enterprise managers to effectively manage internal business processes, production processes and service processes on the basis of information sharing, so as to ensure their rationality and integrity, and at the same time ensure certain dynamics and flexibility.

We describe the three dimensions of flexibility as follows.

1) Dimension of data flexibility

Normalization and standardization of basic data is the premise and cornerstone of the whole SMIS operation [27] [28]. The quality of data seriously affects the efficiency of information system. Only with good basic data can the system be operable and flexible, and the operators of each node will be handy. Otherwise, data can't be docked among systems, and various problems often occur in business processes, and the docking work with the upstream and downstream of the supply chain is even more faltering. Therefore, database design plays an important role in the process of SMIS strategic development planning and design. Analyzing and mining enterprise basic data is an important task for database designers and developers, which is related to the stability of the whole system. In particular, manufacturing enterprises introduce new technologies, such as big data, cloud computing, physical information systems and "5G+ Internet", etc. Faced with a large number and variety of data resources, the standardization of basic data becomes particularly important in information system planning. First, the database system designer analyzes the business process of the enterprise in detail and unifies the data format. Secondly, the designer designs a logical database, which can be separated from the physical database to generate a database based on a system platform. In this way, data flexibility can be realized. Data flexibility dimension is the foundation of three dimensions and the premise of SMIS flexibility strategy. The flexibility of data can make some preparations for data integration of homogeneous or heterogeneous systems.

2) Dimension of process flexibility

From the perspective of business process, SMIS supports customers to participate in the whole process, including order determination, product design and production, logistics and after-sales service, from order placement to maintenance, even including raw material selection and demand forecasting mining. Manufacturing process flexibility refers to the ability to produce different types of products in the same manufacturing plant or production line, while the essence of information system flexibility is that the system can be modularized, and the functions of each system can be assembled and disassembled with these modules to meet the changing needs, support customers to participate in the whole process, improve production efficiency, reduce operating costs and resource waste [29]. The key technologies of Industry 4.0 allow dynamic sharing and provide additional manufacturing services in cloud manufacturing environment, which greatly improves the quality of logistics services [2]. Intelligent cloud manufacturing platform including service modeling and dynamic matching module, intelligent resource allocation optimization module and decision support module can improve the resource efficiency of additional manufacturing services [30]. Under the cloud manufacturing mode, business processes are virtualized and encapsulated into manufacturing services, and enterprises can customize their own manufacturing business applications on the cloud manufacturing platform [31]. At the same time, through modular design, the system meets the needs of recombination and reconfiguration, which is carried out according to management requirements, production line adjustment, raw material supply, design changes and demand changes. This requires SMIS to meet the interconnection between different organizations and systems Different from traditional information systems and traditional manufacturing information systems, SMIS is highly flexible and efficient, and can save operating costs to the greatest extent. For example, after the order is confirmed, the product is in the production state, and the customer puts forward new demand points. SMIS can respond to each department node as quickly as possible, and reduce the inconvenience and waste caused by information islands.

3) Dimension of system flexibility

More and more manufacturing enterprises are seeking the road of transformation, and the IOII is in full swing in China. Information systems are integrated and concentrated to varying degrees, and the introduction of cloud model is gradually becoming the road of strategic transformation for manufacturing enterprises [3]. Under the cloud mode, customers can get free resources in the cloud, and manufacturing enterprises of different jobs can realize interconnection and intercommunication through manufacturing cloud, so that enterprises can only use their own advantages to complete production and achieve a win-win situation [31]. Cloud manufacturing is an intelligent manufacturing system mode with open information, resource sharing and diversified services. Cloud manufacturing services for IOT modularize the systems of many manufacturing enterprises, and can get the maximum and optimal output at the lowest cost [32].

The ultimate goal of the information system strategy of SOM enterprises is to interconnect the subsystems of each department and the subsystems of the upstream and downstream of the supply chain, thus breaking the information islands, reducing the waste of resources and realizing information sharing and system integration. This strategy aims to achieve the flexibility and adaptability of the system to meet the operation of enterprises through quick, dynamic and continuous response in the face of changing customer needs, strategic changes, business process changes and fierce market competition environment. This strategy of the company is "a long-term directional plan to decide how to use information technology". The basic data standardization, business process flexibility and system flexibility of SMIS complement each other. From the perspective of upstream and downstream of supply chain, SMIS supports upstream and downstream cooperative activities such as inventory, materials, procurement, design and transportation, so as to improve productive service and service production. Therefore, the dimension of system flexibility is the essence of three dimensions flexible model and the ultimate goal of SMIS's flexible strategy.

### 2.4. SMIS Performance

Information system is a complex structure, and the resources involved include software, hardware, database, protocol, interface, wiring, network, organizational structure, staff quality and so on. Information system is not only a comprehensive technical system such as computer technology, network technology and database technology, but also a flexible composite system related to the enterprise's management thought, enterprise strategy, enterprise's development level and staff's quality. Information system planning and investment are important issues in enterprise strategic management. On the one hand, the increasing scale of enterprise information system promotes it to become an effective means and way to improve enterprise value, development potential and core competitiveness. On the other hand, in the process of formulating and implementing the strategic plan, the positioning and performance measurement of the information system is also an important work of the enterprise information technology department. How to correctly understand the performance of the information system, so as to understand the contribution of the information system to the enterprise goal, and make better use of and improve the enterprise information system, has become the core issue that enterprises are increasingly concerned about.

SOM enterprises not only emphasize production, but also service, emphasizing the power of value creation [7]. Information systems with excellent performance can not only share information across organizations and departments, but also help enterprises to innovate ideas. The prospect of breaking the information island is to reduce business redundancy, improve communication efficiency, and facilitate inside and outside the organization's customers and suppliers to grasp important information in time. When demand changes, it can effectively save costs, shorten production time and delivery time, reduce resource waste, reduce personnel conflicts between departments, and provide customers with better products and services, ultimately helping enterprises to improve their core competitiveness and return on assets [1] [14] [33] [34]. Because information is open to supply chain partners, manufacturing enterprises have established efficient connections, and various departments within the organization communicate smoothly, which is more likely to collide with new knowledge, new technologies and new concepts, so as to carry out technological innovation, business innovation and product innovation faster and better. With a view to improving production capacity and shortening delivery time, product quality is highly recognized by customers. With the strong technical support of advanced information technology and the backing of information systems that fit the actual situation of enterprises, it is possible for enterprises to achieve higher manufacturing flexibility and accelerate the transformation to intelligent manufacturing.

This paper mainly discusses the relationship between customization, flexibility and performance of service-oriented manufacturing information system, and analyzes the flexibility of information system from three angles: data flexibility, process flexibility and system flexibility. The framework and the constructs are shown in **Figure 1** and **Table 1**.

## 3. Hypothesis Development

According to the previous description, we established the conceptual model as shown in **Figure 2**. The relations and assumptions between constructions will be discussed one by one in the following sub-chapters.

### 3.1. SMIS Customization and Flexibility

Various information systems of traditional manufacturing enterprises are provided by different software suppliers. Therefore, the basic data format is not uniform, the data coding is inconsistent, the hardware system does not support it, each subsystem cannot be effectively connected, and the existing system

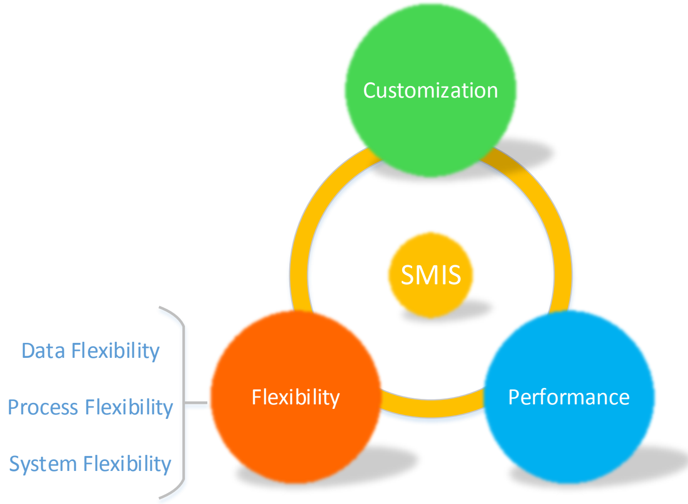


**Figure 1.** Research content.

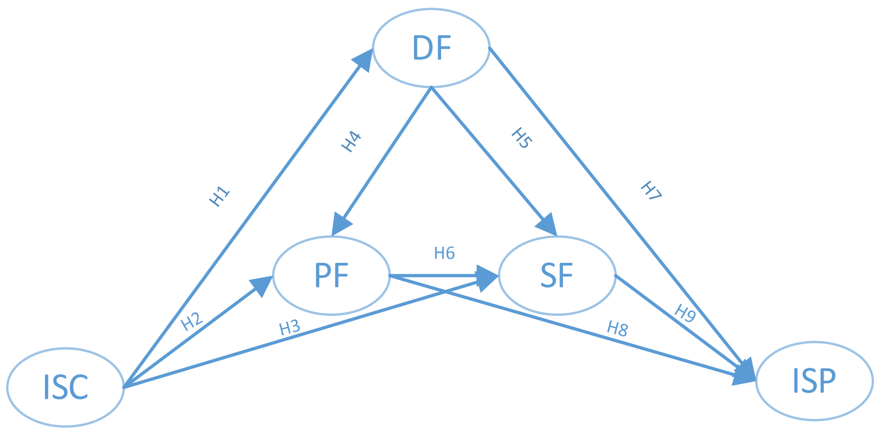


**Figure 2.** Theoretical framework and model.

**Table 1.** Construct descriptions.

| Construct | Description |
|---|---|
| SMIS Customization (ISC) | The degree of customization of information system, which indicates the hardware and application software within the organization is customized according to the actual situation of the organization, in line with the actual production and service requirements of the enterprise. |
| Data Flexibility (DF) | Data is flexible in the whole supply chain, and can be collected automatically. Data definitions in different databases are consistent. |
| Process Flexibility (PF) | Organizational activities and businesses can interact in real time between information systems within upstream and downstream of the supply chain. |
| System Flexibility (SF) | The organization can communicate and coordinate with the upstream and downstream of the supply chain through information system. |
| SMIS Performance (ISP) | With the application of information system, the delivery time is shortened, the delivery quality is improved, the service production is more flexible, the productive service is more personalized, and the return on investment is higher. |

cannot meet the actual business needs. In actual operation, paper file transmission, telephone or email communication often occur, and even manual work is used to reflect the situation with other departments, so the degree of informatization is low. The integration process of informationization and industrialization in most manufacturing enterprises in China is still in the initial stage, and there are not many digital factories, the intelligent manufacturing capability is still weak [6] [11]. Because of the low level of informatization, once there is a problem in any intermediate link, all departments will buck passing, and it is difficult to quickly and accurately find the nodes and main responsible persons with problems, and the communication and feedback with upstream and downstream are even less effective. Customization of information systems is a risky but inevitable task, it helps to keep consistency among information systems, organizational goals and business processes [35]. Information system customization is based on the analysis of organizational production process, business process, organizational structure, combined with organizational and upstream and downstream conditions, to customize a system that meets the actual needs. Contingency theory (CT) holds that in practice, managers should adapt to the changes of the environment and internal conditions of the organization, and there is no fixed and universally applicable management method. The key to successful management lies in full understanding of the internal and external situation of the organization and effective contingency strategies. SMIS customization can effectively integrate the information systems within the organization with the relevant information systems of upstream and downstream enterprises outside the organization. All kinds of SOM enterprises can integrate information systems and industrial control systems on the cloud manufacturing platform, and efficiently access, manage and apply and develop intelligent manufacturing interconnection resources [9] [36] [37].

Scholars have proved that customization, as a key success factor, has a wide impact on the implementation of information systems. The research results of Aversano, Lerina *et al.* show that large-scale integration of information technology projects usually involves customization of software packages [21] [38] [39]. Considering the inefficient system interaction situation that production data and product model are usually separated in the product development process, Qingjin Peng and Chunsheng Yu [40] put forward a visual manufacturing information system to integrate product model and production data. This product data management system can integrate product data in the product development process and quickly review and configure the manufacturing system according to the needs of individual customized products, which ensures the data flexibility and process flexibility of the manufacturing enterprise information system. Integrating personnel, finance, warehousing, master production planning, material requirement planning, limited capacity scheduling, workshop control, procurement, requirement planning, order management, etc. with enterprise resource planning, a set of information system conforming to stakeholders is customized, which inherently includes data consistency. Because customized information system software package is not only the macroscopic configuration of hardware, software and network, but the most important basic work is to plan and analyze data and unify data format, so that the data in different databases in the supply chain are consistent. Only in this way can we ensure the timely collection and sharing of data. For example, the data collected on programmable logic controller (PLC) must be displayed intact on the workshop control system; the order information and status stored in different databases of the whole supply chain are consistent, which can effectively ensure smooth communication between organizations, and make coordination and resource scheduling among departments be clear at a glance.

The implementation process of a good customized information system will also bring changes to the business processes of enterprises [35] [41], which can effectively ensure the smooth flow of business processes [11], smooth production process and efficient operation of warehousing and logistics, thereby reducing production costs and improving production efficiency [42]. Ilyin, I.V. *et al.* [43] think that in resource-intensive projects like information systems, agile project management allows us to change requirements at any stage of information technology projects, and helps users understand and coordinate planned changes. A good information system can realize personalized customized products and mass customized production, and the customized information system architecture realizes enterprise-wide integration, provides links between value chain partners, integrates business activities, simplifies business processes, and plays an important role in the delivery process of customized products [44]. Sudhaman Parthasarathy and Srinaayan Sharma [35] [41] [45] evaluated the efficiency of ERP system from the customization point of view, studied the relationship between customization degree and efficiency of ERP package, and collected data from information technology suppliers of ERP packages deployed by 12 educational institutions. The empirical research results show that customization has a negative impact on the efficiency of ERP packages. Chandra Mohan Sinnandava *et al.* [46] thinks that proper supply chain integration can reduce the waste of resources in the supply chain, reduce the information asymmetry between organizations, and alleviate the influence of external environment on the supply chain. On the one hand, SMIS customization helps enterprises to obtain relevant information in all aspects in time, including requirements, functions, technologies and strategies, so as to identify related activities and reduce waste of resources [8] [9]. On the other hand, the customized information system is to make overall planning and design integration of the information system according to the actual operating conditions of the enterprise and the whole supply chain [5] [47], which means that the customized information system may affect its system flexibility.

Based on the above description, we have reason to believe that the adoption of customization by service-oriented manufacturing enterprises will have an impact on the flexibility of information systems, and put forward three assumptions:

H1. The degree of customization of information system is positively correlated with data flexibility.

H2. The degree of customization of information system is positively correlated with process flexibility.

H3. The degree of customization of information system is positively related to the flexibility of the system.

### 3.2. Different Dimensions of Information System Flexibility

In the research of information system, data quality has not been paid enough attention so far. Data quality is very important to the operation of information systems, and low-quality data in information systems will bring great risks to business operations and management decisions. In the research of information processing theory (IPT), Good basic data of SMIS is helpful for system users to receive, understand, store, extract and feed back information and knowledge, and provides a foundation for efficient connection of information systems based on manufacturing cloud across functions and organizations, and supports business changes, organizational structure changes, strategic changes and demand changes. Radhakrishnan [13] thinks that information system integration within an organization is the electronic connection between the company's information technology applications and data acquisition and storage systems, which is helpful to share accurate and timely information and support cross-functional business processes. Zhao Xiande [48] believes that internal integration is the integration of all information systems within an organization, which enables information to be transmitted to upstream and downstream partners of the supply chain in a timely manner, helping enterprises to quickly respond to decisions and respond to market changes.

Knowledge in enterprises is partly and completely shared by various means, such as text, technical system, words and deeds, etc. This knowledge integration and creation will produce new knowledge that can bring economic value. Knowledge-based view theory (KBV) holds that an enterprise is a knowledge processing system, and the source of its core competence is the invisible knowledge. Therefore, in order to improve the utilization rate of knowledge, enterprises should not only integrate and innovate internal knowledge to create new valuable knowledge, but also obtain effective knowledge needed by enterprises from outside. We know that remote data integrity is very important for the security of cloud-based information systems. Quanyu Zhao *et al.* [49] constructed a new privacy-preserving remote data integrity check scheme for the IOT information management system, which does not involve trusted third parties. The scheme uses ElGamal cryptosystem, bilinear pairings and blockchain to support efficient public batch signature verification and protect the security and data privacy of the IOT system. Yoram Timmerman and Antoon

Bronselayer [27] put forward a framework for measuring the quality of data by using the principle of rule-based measurement. This framework can deal with data quality problems caused by incorrect execution and description of data collection and verification process. Considering that the data quality of information systems should be controlled, Qi Liu *et al.* [28] put forward a nonlinear programming optimization model with control resource constraints, which uses Petri nets to capture the data quality problems and how data are generated, disseminated and accumulated in information systems. They take the warehouse management system of an e-commerce company as an example to verify the effectiveness of the model. The research results show that the optimal resource input level of data operation nodes is directly proportional to its downstream communication potential. Baruffaldi, Giulia *et al.* [37] designed a decision support tool considering the cost of information sharing, the scarcity visibility of customer data and the uncertainty of quantitative return on investment, so as to help the manager of the third-party logistics company decide the appropriate customization of warehouse management system. The empirical results verified the effectiveness of customizing the third-party logistics warehouse in the field of biomedical products.

Therefore, the flexibility of SMIS data will promote the dissemination and sharing of knowledge, and good basic data will help to mine invisible knowledge. For redundant or bad business processes, when implementing customized systems, managers will reform and upgrade business processes according to the requirements of enterprise development strategy and customized systems, so as to improve process flexibility. This will help enterprises to acquire new knowledge and new concepts, upgrade new technologies (integrating new information technologies into industrial technologies), high-tech products and innovative services (service methods, service contents, etc.), improve communication and coordination with upstream and downstream partners in the supply chain, and then optimize system flexibility to ensure that the organization is invincible in uncertain environment. In view of the industry particularity of SOM enterprises, decision-makers should focus on modular design when planning information systems. Modular design can simplify business processes and improve the efficiency of information transmission. Good process flexibility helps enterprises to make full use of internal resources to achieve system flexibility between upstream and downstream information systems in the supply chain. Therefore, there is a certain relationship between different dimensions of information system flexibility. Here we propose three assumptions:

H4. Data flexibility is positively related to process flexibility.

H5. Data flexibility is positively related to system flexibility.

H6. Process flexibility is positively related to system flexibility.

### 3.3. IS Flexibility and IS Performance

According to resource-based view (RBV) theory, enterprises have different tangible and intangible resources, which can be transformed into unique capabilities. These unique resources and capabilities are the source of lasting competitive advantages for enterprises. At any time, enterprises will have resource reserves after making decisions based on previous resource allocation, which will limit and influence the next decision of enterprises. In other words, the differences in resources between enterprises result in different profitability of enterprises, and also lead to enterprises with superior resources gaining economic advantages. Based on the needs of customers and users of application software, enterprises use various integration technologies such as function integration, network integration and software interface integration to plan and design independent and unrelated subsystems in the supply chain and integrate them into a coupled and efficient system. Integrated information system can effectively coordinate and manage enterprise resources, plan and co-ordinate internal production, procurement and inventory information, as well as corresponding knowledge and activities, so as to improve operational efficiency. When the external environment (characteristics of customers and suppliers) changes, manufacturers should formulate, select and implement strategies to keep both internal structural characteristics and external environmental characteristics. In an open market environment, inter-organizational activities are frequent, and an external information system is needed to control, process business, provide data, coordinate activities and communicate with supply chain partners [12] [13]. This external system allows organizations to integrate upstream and downstream related resources, provide data visibility for customers and suppliers, and allow online information sharing of the entire supply chain [13] [46] [48].

In view of the frequent occurrence of a large number of manual processes and product variants in the rework field of manufacturing companies, which directly weakens the process verification and documentation, makes the work plan and assistance system inflexible. Rainer Müller *et al.* [25] put forward a data and information structure to configure flexible work plans for manual workstations on the rework site. This flexible work plan considers error reasons, employee qualifications and product, process and resource data. Zbigniew Tarapata *et al.* [26] put forward a data-driven machine learning system, which can improve the efficiency of the distribution process of goods and services. Tan, BW and Lo, TW [10] took the office automation (OA) system as the research object, and found that customizing the user interface can affect the success of the information system without considering the cognitive style of users. Arafat Salih Aydiner *et al.* [50] think that there is a positive correlation between information system capability and organizational performance, with decision-making performance and business process performance as intermediary variables. Adam S. Maiga *et al.* [12] thinks that the internal integration and external integration of information systems have a significant positive correlation with cost and quality performance, and have a positive effect on the profitability of enterprises through cost and quality performance. Abirami Radhakrishnan *et al.* [13] think that external integration with supply chain partners and implementation of inter-organizational information systems play an intermediary role in the relationship between the use of internal organizational structure and buyer-supplier capabilities.

Based on the literature and our research data of the IOII of many manufacturing enterprises in the Pearl River Delta of China, we believe that the customized information system is conducive to good communication between managers and internal employees and external partners of enterprises, so as to help decision-making. Therefore, we believe that a good customized information system will positively affect its flexibility, and then affect its performance. We put forward the last three assumptions:

H7. Data flexibility is positively correlated with information system performance.

H8. Process flexibility is positively correlated with information system performance.

H9. System flexibility is positively correlated with information system performance.

## 4. Research Design and Methods

### 4.1. Questionnaire Design

The questionnaire of this study consists of five parts. The first part is to build ISC through 7 indicators, the second part is to build DF through 3 indicators, the third part is to build PF through 4 indicators, the fourth part is to build SF through 6 indicators, and the fifth part is to build ISP through 10 indicators, with a total of 30 indicators. The questionnaire used a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). The sample of the questionnaire is shown as items in **Table 2**.

### 4.2. Data Collection

HPM refers to the ability of manufacturing enterprises to achieve continuous improvement through management practices, information technology and manufacturing practices, to improve the operational efficiency and performance, and to gain global competitiveness. HPM is an international benchmark research for manufacturing plants, which was initiated in the United States in the name of World-class Manufacturing (WCM) since 1989. The main goal of HPM has been to determine the advanced production practices (APPs) that determine the outstanding performance of manufacturing industry [48] [51] [52]. Through the questionnaire survey of different types of high-performance manufacturing factories in the world, HPM project understands the practice and principles behind the excellent performance of manufacturing industry, in order to introduce new technologies quickly and successfully, and then improve the efficiency and quality of the production process. With more research teams from different countries joining the project, many scholars have done a lot of research on the data of

Table 2. Items and factor loading in the CFA mode.

| Constructs | Items | Standardized Factor loading |
|---|---|---|
| ISC (Cronbach's Alpha = 0.888) | ISC1: Please rate the extent of customization of master production schedule. | 0.601 |
| | ISC2: Please rate the extent of customization of material requirements planning. | 0.753 |
| | ISC3: Please rate the extent of customization of finite capacity scheduling. | 0.589 |
| | ISC4: Please rate the extent of customization of shop floor control. | 0.480 |
| | ISC5: Please rate the extent of customization of purchasing. | 0.770 |
| | ISC6: Please rate the extent of customization of demand planning. | 0.528 |
| | ISC7: Please rate the extent of customization of order management. | 0.752 |
| DF (Cronbach's Alpha = 0.898) | DF1: Automatic data capture (e.g. bar code) systems are used across the supply chain. | 0.707 |
| | DF2: Definitions of key data elements (e.g., customers, orders, part numbers) are common across the supply chain. | 0.911 |
| | DF3: Data stored in different databases (e.g., order status) is consistent across the supply chain. | 0.878 |
| PF (Cronbach's Alpha = 0.856) | PF1: To what extent do you agree with supply chain planning applications, such as demand planning, transportation planning and manufacturing planning communicate in real time. | 0.760 |
| | PF2: To what extent do you agree with supply chain transaction applications, such as order management, procurement, manufacturing and distribution communicate in real time. | 0.763 |
| | PF3: To what extent do you agree with supply chain applications with internal application within our organization (such as enterprise resource planning) communicate in real time. | 0.762 |
| | PF4: To what extent do you agree with customer relationship applications with internal applications in our company communicate in real time. | 0.489 |
| SF (Cronbach's Alpha = 0.854) | SF1: To what extent does your information system facilitate knowledge about inventory mix/levels to suppliers. | 0.628 |
| | SF2: To what extent does your information system facilitate scheduling and tracking of delivery to suppliers. | 0.58 |
| | SF3: To what extent does your information system facilitate purchase orders to suppliers. | 0.690 |
| | SF4: To what extent does your information system facilitate demand forecasting to suppliers. | 0.536 |
| | SF5: To what extent does your information system facilitate knowledge about inventory mix/levels to customers to customers. | 0.597 |
| | SF6: To what extent does your information system facilitate delivery scheduling and tracking to customers. | 0.577 |

**Continued**

| | | |
|---|---|---|
| ISP (Cronbach's Alpha = 0.974) | ISP1: Please indicate your opinion on the extent to which your information system have achieved value creation. | 0.772 |
| | ISP2: Please indicate your opinion on the extent to which your information system have achieved innovative ideas. | 0.809 |
| | ISP3: Please indicate your opinion on the extent to which your information system have achieved cost savings. | 0.827 |
| | ISP4: Please indicate your opinion on the extent to which your information system have achieved high perceived quality of our products. | 0.879 |
| | ISP5: Please indicate your opinion on the extent to which your information system have achieved greater manufacturing flexibility. | 0.828 |
| | ISP6: Please indicate your opinion on the extent to which your information system have achieved reduced delivery time. | 0.794 |
| | ISP7: Please indicate your opinion on the extent to which your information system have achieved better service to our customers. | 0.795 |
| | ISP8: Please indicate your opinion on the extent to which your information system have achieved stronger focus on our core competencies. | 0.867 |
| | ISP9: Please indicate your opinion on the extent to which your information system have achieved improved return on assets. | 0.838 |
| | ISP10: Please indicate your opinion on the extent to which your information system have achieved access to state-of-the-art techniques and expertise. | 0.783 |

these rounds of questionnaires [52] [53] [54] [55]. This project provides a solid foundation for manufacturing enterprises to improve their manufacturing process capabilities (especially the processing of new materials) and gain competitive advantages.

This study takes "service-oriented manufacturing enterprises" as the analysis unit, and the data comes from the third HPM project. This project mainly studied the following 16 kinds of practices: adaptability (A), business service (BS), constraint management (CM), environment (E), human resources (HR), improvement (I), information system/information technology (IS/IT), just-in-time production/lean manufacturing (LM), manufacturing strategy (MS), new product development (NPD), performance (P), quality management (QM), supply chain management (SCM), sustainability (S), technology (T) and total production maintenance (TPM). Because these three industries (machinery, electronics and transportation components) are facing fierce competition and rapid transformation, and they are the main departments of industrial manufacturing in many countries in the world. Therefore, a questionnaire survey was conducted on randomly selected manufacturing companies in these three industries, and there were about 85 manufacturers in each industry. These manufacturing plants are located in 11 countries, including Brazil, China, Spain, Finland, Germany, Israel, Italy, Japan, South Korea, Switzerland and Taiwan, with about 25 manufacturers in each country. Because there are usually no complex supply chain management activities in small-scale enterprises, each manufacturing factory where we collect data has more than 100 employees, which ensures the reliability of project data. In the process of data collection, we usually call potential interviewees first, and then mail them questionnaires. Each participating manager has appointed a survey coordinator who is responsible for distributing and collecting questionnaires in the factory. Sealed envelopes are used to ensure anonymity and reliability of data collection. In each manufacturing enterprise, various respondents who know the internal and external operations of the enterprise will answer the questionnaire. Respondents include supervisors, managers and direct workers. Complete questionnaires from all interviewees in each company are combined into one questionnaire package. 260 questionnaires were distributed in 230 enterprises, and 184 questionnaires were available, with a response rate of about 70%. This response rate indicates that non-response bias is not an important issue for this study. Data description is shown in Table 3.

## 5. Results of Analysis

In this section, we first introduce descriptive statistics. Then we test the hypothesis and make further analysis.

Table 3. Survey respondent demographics.

| | Number | % of Total |
|---|---|---|
| **Panel A: Company location** | | |
| BRA | 20 | 8 |
| CHN | 30 | 11 |
| ESP | 25 | 10 |
| FIN | 17 | 7 |
| GER | 28 | 11 |
| ISR | 26 | 10 |
| ITA | 29 | 11 |
| JPN | 21 | 8 |
| KOR | 26 | 10 |
| SWE | 9 | 3 |
| TWN | 30 | 11 |
| **Panel B: Nature of company** | | |
| Electronics | 97 | 37 |
| Machinery | 91 | 35 |
| Transportation Components | 73 | 28 |

### 5.1. Measurement Development

We use a rigorous process to develop and validate the constructs used in this study. The validity of the content is guaranteed by careful literature review. The data are also standardized by industry and country to eliminate the influence of these variables and enhance the robustness of the survey results. SPSS and AMOS were used for analysis. At first, SPSS 19.0 was used for confirmatory factor analysis (CFA).

According to consistency test in Table 2, we can know that all Cronbach's Alpha is higher than 0.8, and the reliability coefficient alpha value of the total table is as high as 0.913, indicating that the selected items have good consistency. The KMO of factor analysis is 0.882, which shows that the factor analysis in this study has good structural validity. The p value of Bartlett tests is 0.000, which indicates that the correlation coefficient matrix of factors is not identity matrix, and it can extract less common factors and explain most variance at the same time, that is, the validity is good. According to Table 2, we find that the loads of all factors are greater than 0.5 except ISC4 and PF4 (in fact, 0.480 and 0.489 are very close to 0.5), and 73.7% of the loads are greater than 0.6, which indicates that factors have a strong influence on variables in this study.

Then, we extract the main factors. As shown in Table 4, five factors are extracted, and the cumulative contribution rate is 71.819%, indicating that the cumulative effectiveness of common factors on the scale is very good, and the data variability ratio explained by factors is relatively high, which means the number of main factors used in this study can explain enough total variation in the data.

Since each factor load reflects the correlation degree between the original variable and a common factor, we can also find from Table 4 that the factor load of each variable in each main factor is greater than 0.5, and the vast majority (83.3%) is greater than 0.7, which shows that the extracted five main factors can explain each variable well. Because the total variance explained by the principal factors is greater than 60% (71.819%), the questionnaire has good structural validity.

According to Table 5, in which $\mathrm{AVE} = \sum \lambda^2 / n$, $\mathrm{CR} = \left(\sum \lambda\right)^2 \Big/ \left[\left(\sum \lambda\right)^2 + \sum \delta\right]$, $\lambda$ is the factor loadings, $\delta$ is the residual variances, calculate main factors $f_i = \sum \lambda_j \eta_j, i = 1, \cdots, 5$, $j$ is the number of factors of the $i^{\text{th}}$ principal component, $n$ is the corresponding factor value. We know that AVE of all constructs is greater than 0.5, and the convergence validity is good. CR is greater than 0.8, and the CR values of IS customization, Data Flexibility and IS Performance are greater than 0.9, which indicates that the constructive reliability of the constructs is high.

In order to test the discriminant validity, we verified the close relationship between the tested items and their constructions and other constructions. It can be seen from Table 6 as bivariate correlation analysis that the diagonal value of each column is larger than the other values of each column, and they are all

Table 4. Load matrix in the CFA mode.

| Items | Factor 1 (ISP) | Factor 2 (ISC) | Factor 3 (SF) | Factor 4 (PF) | Factor 5 (DF) |
|---|---|---|---|---|---|
| ISC1 | 0.028 | 0.771 | 0.027 | 0.064 | 0.035 |
| ISC2 | 0.130 | 0.846 | 0.140 | −0.006 | 0.022 |
| ISC3 | 0.043 | 0.758 | −0.008 | 0.114 | 0.003 |
| ISC4 | 0.107 | 0.553 | −0.191 | 0.356 | −0.001 |
| ISC5 | 0.070 | 0.865 | 0.096 | −0.082 | 0.042 |
| ISC6 | 0.035 | 0.680 | 0.072 | 0.227 | 0.085 |
| ISC7 | 0.094 | 0.849 | 0.123 | 0.022 | 0.080 |
| DF1 | 0.168 | 0.114 | 0.103 | 0.087 | 0.805 |
| DF2 | 0.155 | 0.066 | 0.088 | 0.101 | 0.930 |
| DF3 | 0.124 | 0.031 | 0.056 | 0.09 | 0.922 |
| PF1 | −0.002 | 0.179 | 0.392 | 0.753 | 0.09 |
| PF2 | −0.015 | 0.112 | 0.368 | 0.782 | 0.054 |
| PF3 | 0.018 | 0.046 | 0.251 | 0.827 | 0.114 |
| PF4 | 0.183 | 0.177 | 0.268 | 0.583 | 0.113 |
| SF1 | 0.068 | 0.096 | 0.757 | 0.039 | 0.201 |
| SF2 | 0.113 | 0.025 | 0.725 | 0.202 | 0.011 |
| SF3 | 0.067 | −0.081 | 0.800 | 0.192 | 0.054 |
| SF4 | 0.179 | 0.108 | 0.641 | 0.259 | 0.117 |
| SF5 | 0.043 | 0.136 | 0.750 | 0.114 | 0.012 |
| SF6 | 0.046 | 0.010 | 0.658 | 0.364 | −0.098 |
| ISP1 | 0.864 | 0.040 | 0.088 | 0.027 | 0.126 |
| ISP2 | 0.881 | 0.075 | 0.098 | 0.047 | 0.125 |
| ISP3 | 0.903 | 0.048 | 0.02 | −0.023 | 0.087 |
| ISP4 | 0.922 | 0.133 | 0.059 | 0.045 | 0.075 |
| ISP5 | 0.898 | 0.100 | 0.065 | 0.072 | 0.037 |
| ISP6 | 0.876 | 0.097 | 0.133 | 0.01 | 0.009 |
| ISP7 | 0.877 | 0.103 | 0.078 | 0.033 | 0.083 |
| ISP8 | 0.928 | 0.041 | 0.044 | 0.033 | 0.035 |
| ISP9 | 0.911 | 0.012 | 0.082 | 0.033 | 0.017 |
| ISP10 | 0.873 | 0.003 | 0.018 | 0.064 | 0.128 |

Table 5. Reliability and validity measures in the CFA mode.

| | AVE | CR |
|---|---|---|
| IS Customization | 0.589 | 0.908 |
| Data flexibility | 0.788 | 0.917 |
| Process flexibility | 0.551 | 0.828 |
| System flexibility | 0.524 | 0.868 |
| IS Performance | 0.798 | 0.975 |

Table 6. Correlations of latent variables.

| | Mean | SD | ISC | DF | PF | SF | ISP |
|---|---|---|---|---|---|---|---|
| ISC | 2.777 | 0.032 | 0.767a | | | | |
| DF | 3.297 | 0.045 | 0.154* | 0.888 | | | |
| PF | 3.456 | 0.156 | 0.273** | 0.236** | 0.742 | | |
| SF | 3.458 | 0.076 | 0.165** | 0.198** | 0.587** | 0.724 | |
| ISP | 2.618 | 0.010 | 0.176** | 0.255** | 0.124** | 0.196** | 0.893 |

Note: $^{**}p < 0.01$, $^{*}p < 0.05$, a is the AVE is shown on the diagonal of the matrix.

significant (under different significance levels), which shows that this study has good discriminant validity.

## 5.2. Tests of Structural Model

In order to clarify mediation effect, analyze all possible indirect effects of customized information system on system performance, and direct and indirect effects between different dimensions of information system flexibility, we analyzed different paths of the mode by regression analysis. Panel A and B in Table 7 show that the paths of ISC→DF→ISP, ISC→DF→PF→SF→ISP, ISC→PF→SF→ISP and DF→PF→SF→ISP are significant, because under 95% confidence interval, the minimum value of standardized indirect effect is positive, indicating that it has reached the significant level. Other paths do not meet the significance level. In other words, the flexibility of information system mediates the influence of customized information system on system performance, which can be divided into three kinds—a: data flexibility, b: data flexibility, process flexibility and system flexibility, and c: process flexibility and system flexibility. According to panel C in Table 7, we can know that in the analysis of intermediary effect of SF on PF and ISP, $a = 0.587$, $b = 0.188$, $c = 0.124$, $c' = 0.014$, the contribution rate of intermediary effect to total effect is $M = (ab/c) * 100\% = 88.9\%$, which indicates that SF exert a tremendous indirect influence. Because the return coefficients $a, b, c$ all satisfy sig < 0.05, $c'$ satisfy sig > 0.05, the minimum value of standardized indirect effect is less than 0 under 95% confidence interval, so $a, b, c$ is significant but $c'$ is not significant. This shows that system flexibility plays a completely mediating role between process flexibility and information system performance, that is, the impact of process flexibility on information system performance is entirely through system flexibility.

According to the results of path analysis, we used AMOS 24 to do Exploratory Factor Analysis (EFA). In the structural equation model, we use goodness of fit index to test the fitting degree between the model established and the data. The P value of chi-square testis 0.188, which does not reach the significance level of 0.05, indicating that there is no significant difference between the data and the model, that is, the observed data can be adapted to the hypothetical model.

It can be seen from Table 8 that the chi-square value of this study is 6.159,

**Table 7.** Testing of the mediation effects.

| From→To | Standardized indirect effect | S.E. | 95% CI for standardized indirect effect | | $t$ | $p$ |
|---|---|---|---|---|---|---|
| | | | Lower | Upper | | |
| **Panel A: ISC→ISP** | | | | | | |
| Total | 0.0455 | 0.0278 | −0.0021 | 0.1089 | | |
| ISC→DF→ISP | 0.0329 | 0.0218 | 0.0034 | 0.9290 | | |
| ISC→DF→PF→ISP | −0.0018 | 0.0032 | −0.0130 | 0.0020 | | |
| ISC→DF→SF→ISP | 0.0017 | 0.0023 | −0.0005 | 0.0105 | | |
| ISC→DF→PF→SF→ISP | 0.0030 | 0.0026 | 0.0001 | 0.0124 | | |
| ISC→PF→ISP | −0.0136 | 0.0206 | −0.0632 | 0.0201 | | |
| ISC→PF→SF→ISP | 0.0232 | 0.0129 | 0.0023 | 0.0553 | | |
| ISC→SF→ISP | −0.0001 | 0.0095 | −0.0202 | 0.0203 | | |
| **Panel B: DF→ISP** | | | | | | |
| Total | 0.0264 | 0.2200 | −0.0099 | 0.0787 | | |
| DF→PF→ISP | −0.0066 | 0.0204 | −0.0554 | 0.0271 | | |
| DF→PF→SF→ISP | 0.0226 | 0.0145 | 0.0012 | 0.0587 | | |
| DF→SF→ISP | 0.0104 | 0.0124 | −0.0068 | 0.0473 | | |
| **Panel C: PF→ISP** | | | | | | |
| Direct effect | 0.1240 | 0.0620 | | | 2.0080 | 0.0460 |
| PF→SF | 0.5870 | 0.5000 | | | 11.653 | 0.0000 |
| PF and SF→ISP | 0.0140 | 0.0760 | −0.1350 | 0.1630 | 0.1820 | 0.8560 |
| | 0.1880 | 0.0760 | 0.0390 | 0.3370 | 2.4850 | 0.0140 |

**Table 8.** Reliability and validity measures in the EFA mode.

| RMR | SRMR | RMSEA | GFI | AGFI | NFI | RFI | IFI | CFI | $\chi^2$ | Df |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.034 | 0.034 | 0.046 | 0.991 | 0.965 | 0.965 | 0.913 | 0.987 | 0.987 | 6.159 | 4.000 |

and the degree of freedom is 4, so $\chi^2/df = 1.54$, indicating that the overall fitting degree of the sample is good. RMR, RMSEA and SRMR are both less than 0.05 (0.034, 0.046 and 0.034, respectively). Except the RFI (0.913), GFI, AGFI, NFI, IFI and CFI are all greater than 0.95, which shows that the model fits very well.

It can be seen from **Table 9**, since the critical ratios (C.R.) of all constructs satisfy $|\mathrm{CR}| > 1.96, p < 0.05$, all the listed paths have passed the significance test. Among them, the return coefficient of the paths DF→PF, ISC→PF, PF→SF, DF→ISP are significant at $p < 0.001$ level, and return coefficient of the path ISC→DF, SF→ISP are significant at $p < 0.05$ level. So we accept the original hypothesis.

Based on the above analysis, we get the path results of structural equation model as shown in **Figure 2**.

**Table 9.** Summary of standardized structural model parameter estimates.

| | Standardized Regression Weights | S.E. | C.R. | *p* |
|---|---|---|---|---|
| ISC→DF | 0.154 | 0.062 | 2.510 | 0.012 |
| DF→PF | 0.199 | 0.059 | 3.355 | *** |
| ISC→PF | 0.241 | 0.060 | 4.067 | *** |
| PF→SF | 0.587 | 0.050 | 11.676 | *** |
| SF→ISP | 0.152 | 0.060 | 2.525 | 0.012 |
| DF→ISP | 0.226 | 0.060 | 3.761 | *** |

Note: ***$p < 0.001$.

It can be seen from Table 8, Table 9 and Figure 3 that assumptions 1, 2, 4, 6, 7 and 9 are valid, while assumptions 3, 5 and 8 are not. It shows that customization of SMIS has a significant positive effect on data flexibility and process flexibility, while data flexibility has a significant positive effect on process flexibility, process flexibility has a significant positive effect on system flexibility and system flexibility has a significant positive impact on system performance. In the process of the influence of customized information system on process flexibility, besides direct influence, data flexibility plays a partial intermediary role. In the process of the impact of customized information system on system performance, data flexibility plays a part of intermediary role, process flexibility and system flexibility play a part of chain intermediary role, and data flexibility, process flexibility and system flexibility also play a part of chain intermediary role. In other words, the impact of customized information system on system performance is partly influenced by data flexibility, partly by process flexibility and system flexibility, and partly by data flexibility, process flexibility and system flexibility. Besides its own direct effect, the impact of data flexibility on system performance is partly influenced by process flexibility and system flexibility. However, the influence of process flexibility on system performance is completely influenced by system flexibility, and there is no direct effect. Generally speaking, customization of SMIS will positively affect its flexibility, and then affect system performance. At the same time, information system flexibility plays a chain intermediary role between customization and performance.

Based on the above analysis, we believe that SOM enterprises pay special attention to the coordination and information sharing between upstream and downstream of the supply chain, and information system customization can provide tools and platforms beneficial to the smooth and efficient work of upstream and downstream stakeholders in the supply chain. SOM enterprises pay more attention to the information and resources integration of upstream and downstream among the supply chain, and break the information island. Integrate inventory information with supplier information to realize inventory information sharing, and then improve inventory control, inventory analysis and inventory management. Perfect inventory information sharing can reduce inventory accumulation, inventory holding cost, storage cost, transaction cost and

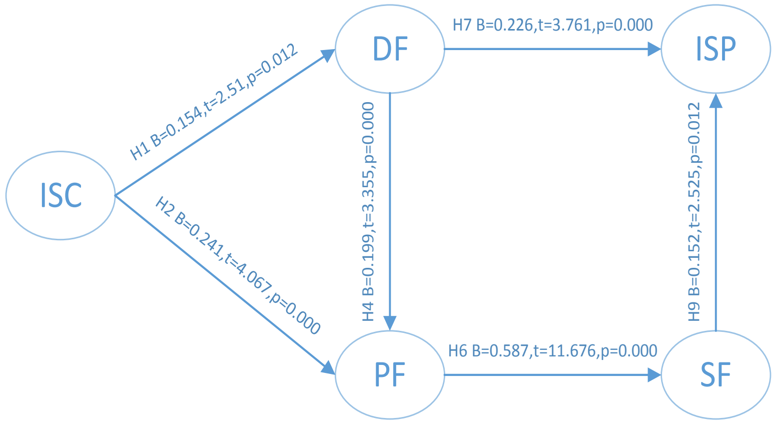


**Figure 3.** Estimated results of the SEM model.

information acquisition cost, as well as procurement cost. Integration with downstream customers in the supply chain (including wholesalers, retailers and individual customers) to realize customer participation in the whole process mainly refers to sharing market information with major customers, establishing quick ordering system, following up and receiving feedback, frequent regular contact, sharing sales information, sharing demand forecast information, sharing inventory information and sharing production plan information. Thus can effectively improve demand forecast, inventory management, design management, order management, production control and service tracking. In addition to external integration, information integration within an organization is also very important, which helps to break the information islands among departments and improve management efficiency, operational efficiency and production efficiency.

To customize an information system that conforms to the current development status and strategic planning of the enterprise, it is necessary to standardize the basic data that needs to be integrated within the organization and upstream and downstream of the supply chain. Of course, we should investigate, analyze and sort out the business processes, tailor the system in line with the strategic development plan of enterprise information systems, and realize real-time data exchange among application software. Based on a good consistent basic database, SMIS can promote coordination activities with suppliers and customers, including inventory, tracking, procurement, demand forecasting and distribution. This greatly improves the performance of information. Therefore, the customization of SMIS has a positive impact on its flexibility and performance.

## 6. Discussion

The model and method proposed in this paper have the following characteristics:

1) Scientifically select the factors that affect the performance of information

systems of manufacturing enterprises. Combined with the literature, the customization, flexibility and performance of the service-oriented manufacturing information system selected in this paper are scientific.

2) Data reliability. All the data used in this study come from the third round of HPM, which has a certain degree of recognition. Scholars have published many high-level papers based on this database.

3) Model validity. Combined with a large number of documents and researches of many enterprises integrating informationization and industrialization in the Pearl River Delta of China, the established model has certain scientific basis. The validity of the model is verified by screening and analyzing the selected HPM related questionnaire data.

4) The effectiveness of the method. In this paper, exploratory factor analysis and confirmatory factor analysis are used to analyze the questionnaire data. Through reliability and validity test, the main factors are extracted, and the path coefficient and fitting index of the model are obtained. Every step is carried out under the guidance of scientific methods.

Of course, there are still some shortcomings in this paper. For example, the cost of information system construction is not considered, and more attention is paid to the state of information system after its completion. We will discuss the impact of cost, organizational climate and leader quality on information system performance in detail in the follow-up study.

## 7. Conclusions

Based on the background of intelligent manufacturing, this study established the conceptual model and research hypothesis of SMIS. Through the analysis of data, the internal mechanism among customization, flexibility and performance of information system in SOM enterprises is revealed. The hypothesis is tested by principal component analysis, process return and structural equation model of 230 manufacturing factory samples. The results show that customized SMIS has a significant positive impact on its performance, partly through data flexibility, partly through process flexibility and system flexibility, and partly through data flexibility, process flexibility and system flexibility. In the study of the relationship between flexibility and performance, data flexibility has a significant positive effect on system performance, and some of them are influenced by process flexibility and system flexibility. The positive impact of process flexibility on system performance is entirely through system flexibility.

Although there are some limitations in this paper, the results of this study show that our path analysis provides a useful method to realize SMIS customization. These findings are particularly meaningful for managers, because the flexibility and performance of information systems are very important for managers, which provide guidance for managers of SOM factories to effectively use information technology, clarify why information systems should be customized in the development process of IOII, and how customized information systems affect information system performance. These results should also be useful for enterprise practitioners and scholars who are interested in information system customization. The conceptual model should also help to develop a more detailed model, which will help researchers in related industries to conduct sample surveys and empirical work in the future, and add new bricks to related theoretical research. Therefore, this study has certain management significance and theoretical significance.

Under the environment of "5G+ Internet", manufacturing enterprises should take customized information systems as strong technical support, integrate upstream and downstream information systems of supply chain to tailor systems that meet stakeholders, so as to improve the production efficiency of manufacturing industry, reshape the manufacturing value chain, condense the core competitiveness of manufacturing industry, accelerate the transformation and upgrading of traditional manufacturing enterprises, break through the bottleneck of existing productivity growth, and commit to deep integration of cutting-edge information technology and manufacturing technology, so as to stand out in the wave of "Industry 4.0" transformation and change, truly realize intelligent manufacturing, and gain a leading position in the global manufacturing industry.

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## Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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