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Research Article

The Knowledge Service Model of Technology-Based SMEs from the Perspective of Value Cocreation

Dongliang Sun [iD],[1] **Wei Yao** [iD],[2] **and Bin Sun**[2]

[1]*Tianjin University, School of Education, No. 92 Weijin Road, Nankai District, Tianjin, China 300072*
[2]*Tianjin University of Science and Technology, School of Economic and Management, 1038 Dagu Nanlu, Hexi District, Tianjin, China 300222*

Correspondence should be addressed to Wei Yao; yaojunwei@tust.edu.cn

China's economy has shifted from the stage of high-speed growth to the stage of high-quality development, and enterprises are facing increasingly complex conditions in the rapidly changing environment. In the process of transformation from "production value growth" to "value-driven", knowledge service plays an important role, which can both increase knowledge innovation capability and export heterogeneous knowledge to the outside world. Under such circumstances, it is necessary to focus on cultivating the capability of knowledge services from the perspective of value cocreation. Starting from this concept, the temporal pattern of data is explored in terms of time span; the service mode of knowledge service to its customers is explored in terms of spatial interaction, and the framework of knowledge service is explored in terms of content structure. It is found that (1) there are five knowledge service models for science and technology-based SMEs, and there exists an efficient service combination of "online+offline"; (2) customers can basically be divided into three categories: passive, active, and neglected. (3) The value cocreation path of knowledge services for science and technology-based SMEs is divided into initial stage-interaction stage-implementation stage; "two-way identification"-"joint participation"-"win-win value" knowledge service value cocreation model.

1. Introduction

Since the 21st century, economic development has shifted from factor-driven to innovation-driven, and innovation is the first driving force leading development and a strategic support for building a modernized economic system. More emphasis has been placed on "respecting knowledge and innovation" and reflecting the value of innovation [1]. 2018 Government Work Report pointed out that driven by the policy of innovation-led development, enterprises have strengthened the construction of technological innovation system, doubled the number of invention patents, promoted a number of major international leading achievements in science and technology, and formed a number of innovation highlands [2]. The 19th CPC National Congress mentioned that the construction of an innovative country should be accelerated, and the word "innovation" appeared 52 times in the full report of the 19th CPC National Congress [3]. China's economic development is shifting from "quantity" to "quality" and from "scale expansion" to "structural upgrading". "This is the need for China's development in the new era.

As enterprises become more intelligent and knowledgeable, there is an urgent need to explore and understand the knowledge service model in the context of value cocreation, which requires understanding the model and environment of knowledge services for small- and medium-sized technology enterprises. The formation of value cocreation has made the knowledge service space more dynamic than before [4]. Knowledge service solutions cross professional and corporate

boundaries, connecting professionals across organizational boundaries through knowledge service spaces, and knowledge services are the driving force of enterprise development and innovation [5]. It plays an important facilitating role. Increasingly, knowledge service interactions occur within the enterprise organizational space, where decentralized stakeholders create opportunities for knowledge creation, collaboration, and service. Knowledge exchange, coordination, and support are considered to be the main communication purposes of enterprise knowledge services, and the sense of identity and belonging of participating members contributes to the sustainability of knowledge services. From the perspective of value cocreation, the core of knowledge services is the process of knowledge experience and complete interaction with customers. In view of this, this paper identifies and analyzes the interactive relationships and service effects of knowledge services of technology-based SMEs, and puts forward countermeasures and suggestions for the development of knowledge services of technology-based SMEs.

2. Literature Review

2.1. Knowledge Services.
The European Commission defined knowledge services in 1995 as a business process that uses expertise to serve other organizations and institutions [6]. Subsequent studies have focused on "knowledge-intensive services" and "knowledge-intensive service industries" [7]. The literature [8] found that knowledge-intensive business services can provide knowledge-based products and services to customers to improve their performance and performance productivity through empirical analysis. The literature [9] found that knowledge-intensive services provide high intelligence and high value-added services to external organizations. Literature [10] compared the knowledge service business in China and EU countries and analyzed the problems in the development of knowledge service business in China. Literature [11] pointed out that knowledge service is a knowledge source and knowledge container in the innovation process, which not only produces innovative knowledge but also transfers heterogeneous knowledge to manufacturing enterprises.

At present, only a few researchers regard enterprises as the subject of knowledge services, and they consider enterprise knowledge services as knowledge service providers providing high value-added knowledge services to their customers [12]. The literature [13] points out that organizational learning and value cocreation driven by knowledge services can break through the uncertainty and resource constraints in the innovation process. The literature [14] places that China is currently developing knowledge-intensive services mainly by enterprises, while the government public sector is mainly the basis for the development of knowledge services. The literature [15] starts from the interaction between knowledge service enterprises and their collaborators to explore their interaction and influencing factors to provide a basis for the improvement of innovation efficiency. The literature [16] has a common drawback that most enterprises' knowledge services fail to provide a list of experts corresponding to the needs of knowledge seekers.

2.2. Cocreation of Value.
Literature [17] proposes that value cocreation is a collaborative process of value creation between enterprise service providers and customers, which can form a new type of partnership. In this cocreation process, value exists in the service system, value is created in the commodity exchange process, and the core is knowledge transfer. Literature [18] customer is a cocreator of value and has the same importance as the company. The literature [19] explains why customers should cooperate with companies to cocreating value, and both parties can benefit from the development, design and promotion of new products. From the dual perspective of value cocreation, the literature [20] summarizes the three stages of innovation bottleneck breakthrough for manufacturing SMEs: innovation bottleneck identification, innovation solution design and innovation bottleneck breakthrough. The literature [21] used Xiaomi as the original data collection object and conducted an exploratory analysis to propose a model of customer participation in brand value creation and five major mechanisms of culture, product, interaction, participation, and communication. The literature [22] found that IT capability plays a mediating role to a certain extent and is an important mediating variable for cocreation of value with customers. Most of the current mainstream value cocreation studies are theoretical studies that focus on the individual level of firms and consumers. Few scholars have focused on the value cocreation process between knowledge-intensive technology firms and their customers, and on the knowledge service model from the perspective of value cocreation.

2.3. Research Significance

2.3.1. Theoretical Significance.
The transition from the "preknowledge service era" to the "postknowledge service era", the postknowledge service era promotes the transformation of knowledge service from the combination of technology and humanities, multidisciplinary intersection and wisdom, etc., and the subjects and objects of knowledge service are also undergoing great changes [23]. How do technology-based SMEs provide knowledge services to their customers? Most of the studies in the existing literature focus on the knowledge services provided by knowledge service institutions or various libraries to enterprises, and there is a lack of in-depth research on this issue for the time being. Starting from the perspective of value cocreation, this paper grafted the value cocreation theory focusing on two-way value cocreation and technology-based SMEs focusing on the joint growth of customers and companies, which is conducive to enriching the existing research on knowledge services of technology-based SMEs, prompting scholars to pay attention to the value cocreation process and providing a new perspective for the research on knowledge services of technology-based SMEs. Therefore, from the perspective of value cocreation, designing corresponding knowledge service models to promote the development of technology-based SMEs can not only further enrich the knowledge service theory but also expand the application of knowledge service theory of technology-based SMEs in the environment of value cocreation.

2.3.2. Practical Significance. Although the scale and quantity of science and technology-based SMEs in China continue to increase, and some enterprises have achieved great success by relying on their own scientific and technological innovation capabilities, there are still a large number of science and technology-based SMEs that develop slowly and cannot adapt to the fierce market competition due to their short establishment time and inexperience [24]. Especially for the emerging knowledge service business, the development of enterprise knowledge service is still in the exploration stage. In order to obtain customer recognition, improve service quality and efficiency, and gain core advantages in market competition, the company urgently needs to reasonably optimize the service model. Therefore, incorporating the idea of value cocreation into the knowledge services of science and technology-based SMEs and studying the value cocreation process in enterprise knowledge services can help science and technology-based SMEs mobilize the subjective initiative of customers more effectively. Nowadays, the knowledge service mode is no longer limited to the traditional information service function. Under the perspective of value cocreation, enterprises can expand the knowledge service business to improve their knowledge reserve and their competitiveness while serving their customers. The research on knowledge service in technology-based SMEs is conducive to promoting the development of technology-based SMEs through corresponding knowledge service design, and reasonable management suggestions are given for customer classification and precise service, which is conducive to the company's more efficient and more precise knowledge service. This paper puts forward corresponding solutions and suggestions for the problems of knowledge services in science and technology-based SMEs found in the research process, and gives certain inspiration to other enterprises, which has important practical significance for the innovation and transformation of knowledge services in science and technology-based SMEs and the satisfaction of customers' knowledge service needs in the future.

3. Study Design

3.1. Research Methods. In this paper, we use a mixed research approach to analyze quantitative and qualitative data in three dimensions: time-space-content. The concept of the hybrid research method is that data have multiple manifestations and attributes, and can be examined from multiple dimensions. Therefore, in order to comprehensively explore the interaction between technology-based SMEs and their knowledge service recipients, and identify and optimize their knowledge service models, a mixed research approach is more appropriate [25].

3.2. Selection of Research Subjects. This study selects Tianjin Pipigo Intelligent Technology Co., Ltd. as the research object for the following reasons:

First of all, Pippi Dog Smart Technology Co., Ltd. is a typical technology-based SME. It was founded in 2012 as a value-added provider of engineering risk system solutions. It has developed several knowledge service platforms and is committed to providing comprehensive solutions in the field of engineering Industrial chain system risk consulting and management services and one-stop solutions. Taking this company as the research object, it has good representativeness and typicality.

Secondly, Pippi Dog Intelligent Technology Limited, whose main business is to provide various management consulting services and professional engineering risk technology solutions, is a typical knowledge service product provider. Doing well in knowledge management and knowledge service is the company's goal. It provides uninterrupted online and offline real-time consulting services with the help of Pipdog knowledge service platform, with various service methods, differentiated service contents and personalized online and offline services. The service brings a different service experience to customers.

Third, Pipigo is more worthy of in-depth study through the author's comparison of several technology-based SMEs and detailed comparison of their related situations, especially the main business of the enterprise and the innovation of the knowledge service model.

In order to meet the needs of the study, to conduct a comprehensive analysis of the research subjects and to improve validity, different data collection methods and data information from different sources are required. In this study, a large amount of company-level and secondary data was collected, including a large amount of internal data collected by the researcher who entered the company in January 2018 for a 12-month follow-up survey, and also data collected through unstructured interviews. Interview texts collected from company leaders and employees; second-hand data mainly come from news reports on the Tianjin Binhai Zhongguancun website, video interviews with the company, and data on the company's website and Pipigou knowledge service platform. To ensure the accuracy and usability of the data, the researchers checked and compared the data collected from the two sources and verified them interactively in the form of interviews, communication, and telephone confirmation, and continuously added new data. Details of the data collection are shown in Table 1.

4. Research Process and Findings

4.1. Time Dimension. In the time dimension, the knowledge service-related data of Pippi Dog Intelligent Technology Co., Ltd. for the past 6 years, including business contract ledgers, enterprise employee data, and reimbursement voucher data, were collected and organized. To understand the development of knowledge service business. By combing the contract ledger of the company within 5 years, the contract ledger of contracting new projects of knowledge services was counted, and the number of new customers per year from 2013 to 2018 was obtained, with the year and date as the horizontal axis. The number is on the vertical axis, and a graph of customer increment has been made. As shown in Figure 1, the number of new customers of Pipdog Intelligent Technology Co., Ltd. reached a peak in 2016, and then decreased year by year. The number of new customers in 2018 was only There are 5, a far cry from 2016.see Figure 1.

TABLE 1: Source and content of research data.

Type	Source	Object	Content	Time
First-hand information	Company research	Platform services, Pipigou Intelligent Technology Co., Ltd.	Platform service module, company business process	A total of 3 times in 2018
	Work participation	Personalized knowledge service, consulting business, customer management	Knowledge service product composition and scheme design	9 months from January to September 2018
	Live interview	Lead 3 times, 0.5 hours/time; staff 11 times, 0.5-1 hour/time	The company's knowledge service business, knowledge service-related content and value embodiment	December 2018- January 2019
Second-hand information	Official information	Tianjin Binhai Zhongguancun Website	News about Pippi Dog, video interviews with company leaders	Real-time collection since 2018
	Website information	Pippi Dog official website, customer service official website	Information on the company's official website and service customer website about Pipidog	Real-time collection since 2018

Similarly, take the year and date as the horizontal axis, and the total number of company customers and the number of company employees' long-distance knowledge services as the vertical axis to make a time series diagram, as shown in Figure 2. It can be seen from the figure that although the growth rate of the number of contracted customers of the company has been decreasing year by year, the total number of contracted customers has been increasing. Under the premise that the total number of customers continues to grow, it is found through statistics that the number of records of remote knowledge services for employees of the company has shown a slight downward trend after 2016, and has not increased with the growth of contracted customers. Comparing the number of trips and customer growth, the study found that as the number of remote knowledge services decreases, so does the number of employees assigned by the company to provide services to customers, and online knowledge services are gradually emerging in the form of online knowledge services. See Figure 2.

4.2. Content Dimension. In the content dimension, Strauss's procedural grounded theory is used to encode the data, and a conceptual theory is gradually constructed through continuous comparison and theoretical sampling. By coding, comparing and summarizing the collected primary data and second-hand data, finally the core categories are abstracted.

4.2.1. Open Coding. With the help of Nvivo software, primary data and secondary data are divided into two groups for open coding, and the two sets of codes are continuously compared to adjust codes with large conceptual differences to ensure coding consistency. In the first round, 432 free nodes were established through coding and comparison; in the second round, 41 tree-like nodes were summarized by classifying and merging the free nodes; Avoid and reduce misclassification and omission in node induction; in the fourth round, similar tree nodes and tree nodes belonging to the same genus are merged again to form 21 new tree nodes, that is, 21 initial categories. Examples of open coding are shown in Table 2.

4.2.2. Spindle Coding. The 21 initial categories of open coding were repeatedly compared and classified, and 6 main categories were obtained after categorization: two-way demand diagnosis, value proposition fit, organizational integration of resources, adjustment of value matching, interactive service realization, value symbiosis and win-win. The spindle codes are shown in Table 3.

4.2.3. Selective Coding. Through the comparison and analysis of the 6 main categories, it can be found that "two-way demand diagnosis" and "value proposition fit" reflect the matching of value demand and value proposition, and are the conditions for knowledge service in value cocreation, which are prefactors; "Organizing resources" and "adjusting value matching" belong to the knowledge service strategy in value cocreation; the dimension of "service interaction realization" is the five modes of knowledge service interaction between the company and customers, which belong to the interaction process of knowledge service between the company and customers; "value symbiosis and win-win" is the result of knowledge service in value cocreation. The core paradigm is shown in Figure 3.

Therefore, the "story line" obtained by selective coding in this case is (1) science and technology-based SMEs and their knowledge service customers jointly diagnose the needs of both parties (two-way demand diagnosis) and identify and discuss service plan design (organization plan discussion), so that the value proposition of the enterprise is in line with the value needs of customers (value proposition fit); (2) use the solution after diagnosis as the standard of service interaction, integrate internal and external resources (organize integration resources), and weigh costs and returns (adjust value matching), formulate action strategies; (3) interact with customers through a variety of service modes (service interaction realization) to realize value propositions and meet customer needs; and (4) technology-based SMEs and customers interact with customers to achieve value symbiosis and win-win (value symbiosis and win-win). Therefore, the core category of this case is on the premise of value fit, technology-based SMEs achieve a win-win value
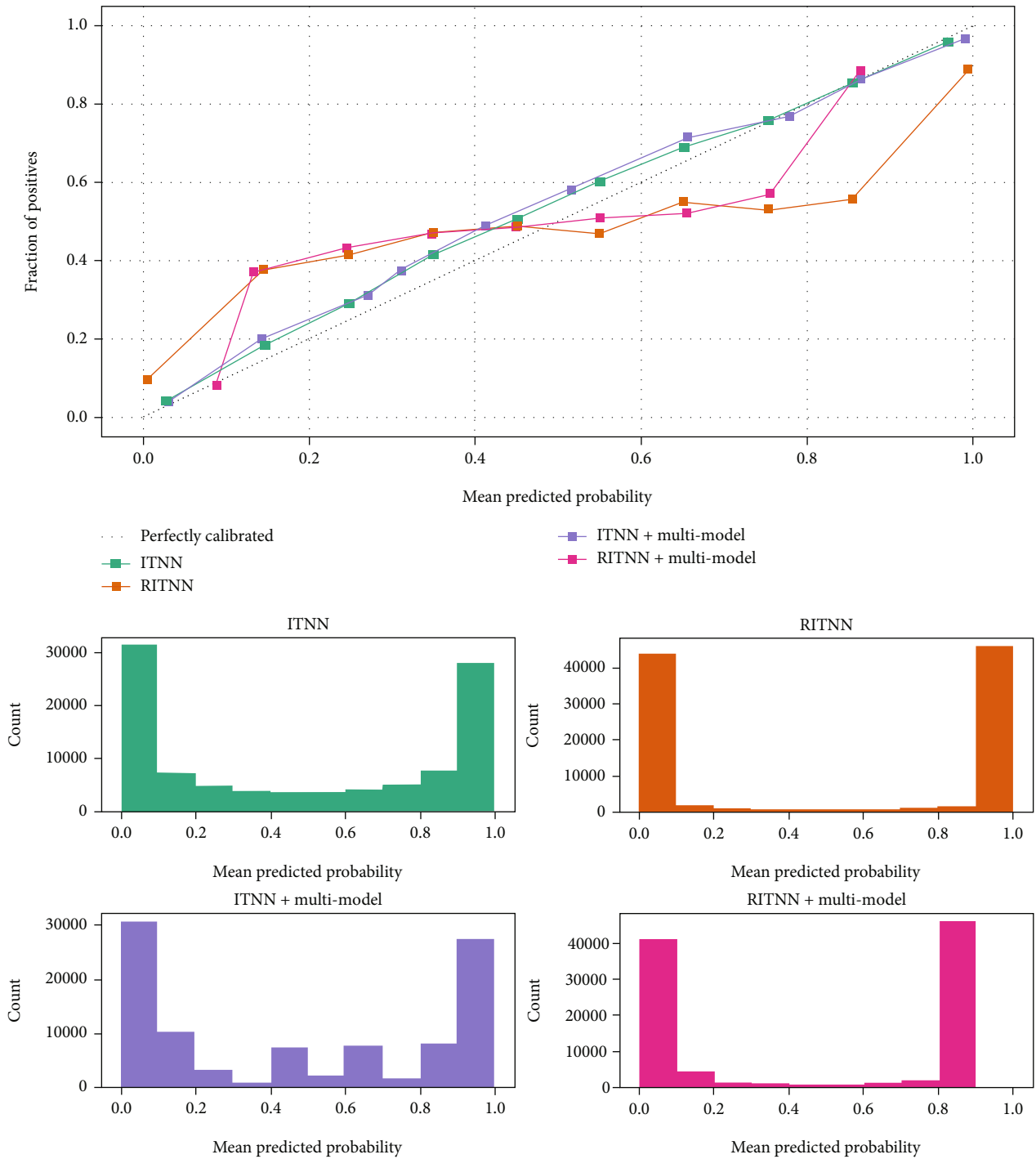
FIGURE 1: Number of new customers in the year.

for both parties through the value cocreation process of interacting with customer knowledge services.

4.3. Spatial Dimension

4.3.1. Visualization of Spatial Interaction. Import the original data matrix into Ucinet, select the 2-modulus matrix for bisection processing, set the cutoff value to 1, and use the functions of Ucinet for multi-angle data analysis and visualization. With the help of Ucinet and Netdraw, the

customer-service clustering model of Pippi Dog Company is constructed, as shown in Figure 4.

As can be seen from the above figure, some of the red circular nodes (customers) and the blue square nodes (services) are less connected and are at the edge of the network structure, which reflects the service and interaction of Pippi Dogs for its customers. Features: dense edge nodes, reflecting the company's lack of service and interaction with customers; isolated nodes in the network structure diagram, indicating that some customers do not enjoy any of the company's
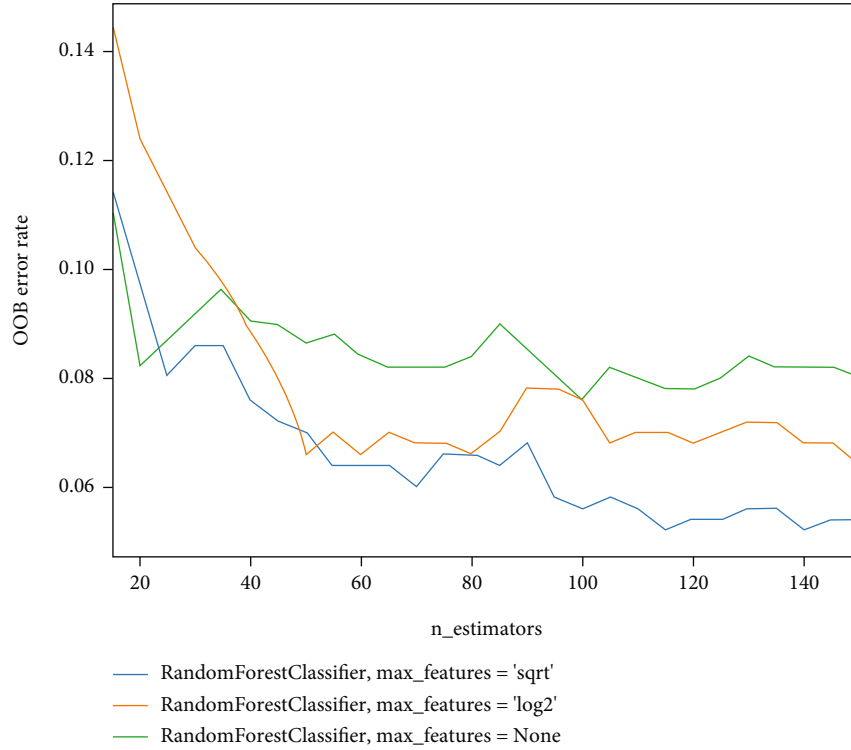
Figure 2: Comparison of the company's annual remote knowledge service times and the total number of customers.

Table 2: Open coding results (partial examples).

Initial statement	Conceptualization	Categorization
All service results generated by Party B under this contract, including knowledge management, transaction plans, contract texts, opinions, investigation reports, memoranda and other consulting documents and service results, can be reasonably used by Party A for free. The case database will be used at the end of the project. Then, open the port according to the needs of Party A. (From the terms of the company's service contract)	A1 customer needs	Customer demand management (A1, A2, A3)
	A2 execute on demand	
	A3 achievement enjoyment	Freemium Service (A4)
	A4 free service	
At the beginning of 2017, we built a 24/7 online "cloud service department" for the client company and the general contracting department for the first time. Based on the cloud platform, we provide clients with legal knowledge services and solve client problems at any time, mainly in the form of client questions and our responses (excerpted from the management of the company's technical department)	A5 online services	
	A6 platform application	Platform Q&A service (A5, A6, A7)
	A7 question answering	
……	……	……

services; "question-and-answer service" deviates from the center of the network and is located above indicating a small range of services, a small number of customers served, and low frequency of active use by customers, without achieving the effect of other services.

4.3.2. Centrality Analysis. Using the constructed 2-module bipartite matrix data, and with the help of the centrality calculation in Ucinet, the customer centrality analysis table and the service mode centrality analysis table are obtained, as shown in Table 4. In the constructed service model network structure, the greater the node centrality, the higher the utili-

zation rate of the knowledge service model represented by the node, or the higher the customer's preference for the service model. As shown in Table 4, among the five knowledge service modes, the node centrality of "professional alternative service" and "platform self-service" is the highest, reaching 101, while the node centrality of "online question and answer service" is the lowest, only 21. According to the analysis results of the intermediate degree, among the five knowledge service modes of the company, the highest utilization rate is "professional alternative service" and "platform self-service", and "platform self-service" is the self-help to obtain the required knowledge or solutions. The special mode is the

TABLE 3: Spindle code.

| Main category	Subcategory	The connotation of the category
Two-way demand diagnosis	Customer demand management	Fully understand customer needs and tap customer resources
	Company demand management	Identify company needs and reduce own costs and risks
	Site visit record	Both parties record the problems through on-site inspections
	Discuss the difference	Hold various needs discussion meetings to exchange problems
Value proposition fit	Suggest solution	The company proposes a series of solutions and service plans
	Organize the discussion	Organizing discussions within and outside the company
	Amendments agreed	Modify the plan and reach an agreement to start the implementation
Organizational integration of resources	Increase knowledge stock	The company continues to acquire knowledge and increase the knowledge stock
	External communication and sharing	Knowledge sharing through online and offline knowledge exchange
	Internal knowledge management	Through knowledge management, the company can better develop knowledge services
Adjust value to match	Benefit sharing model	In order to meet its own value needs, the company increases the profit model
	Weigh input and output	Firms weigh costs and rewards, adjust matching status
Interactive service implementation	Platform Q&A service	Knowledge consultation through platform system
	Professional alternative services	As a service unit, the company solves problems on behalf of customers
	Self-service inquiry service	Customers themselves find the knowledge they need through the platform
	Short-term residency service	The company sends employees to settle in customer units to solve problems
	Freemium service	Free services provided by the company (optional)
Value symbiosis and win-win	Needs met	Both company and customer needs are met
	Participate in the service process	Customer participation in the process of knowledge service
	Operational efficiency improvement	The company and customers jointly improve business performance
	Brand value sublimation	The brand value of the company and customers is enhanced
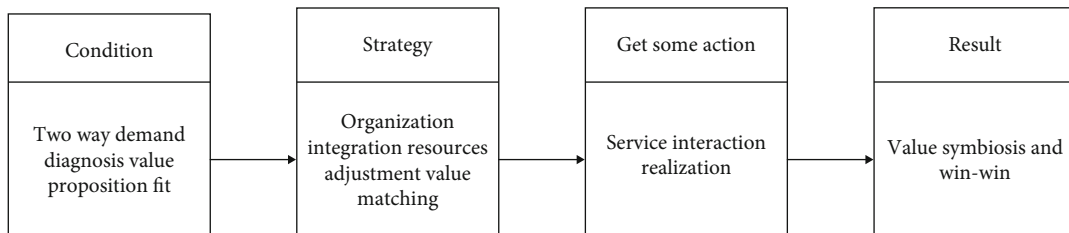
FIGURE 3: Core paradigm model.

embodiment of the customer's active participation in the knowledge service. It is inferred that this service mode is the most commonly used mode when the company's customers actively participate in the knowledge service. On the contrary, the utilization rate of the "online question and answer service" mode is very low. This mode requires dedicated human resources to provide online full-time services, and the company resources occupied did not bring the desired effect to the company.

4.3.3. Singular Value Analysis. Singular value decomposition is a method of matrix thinking, which decomposes a complex
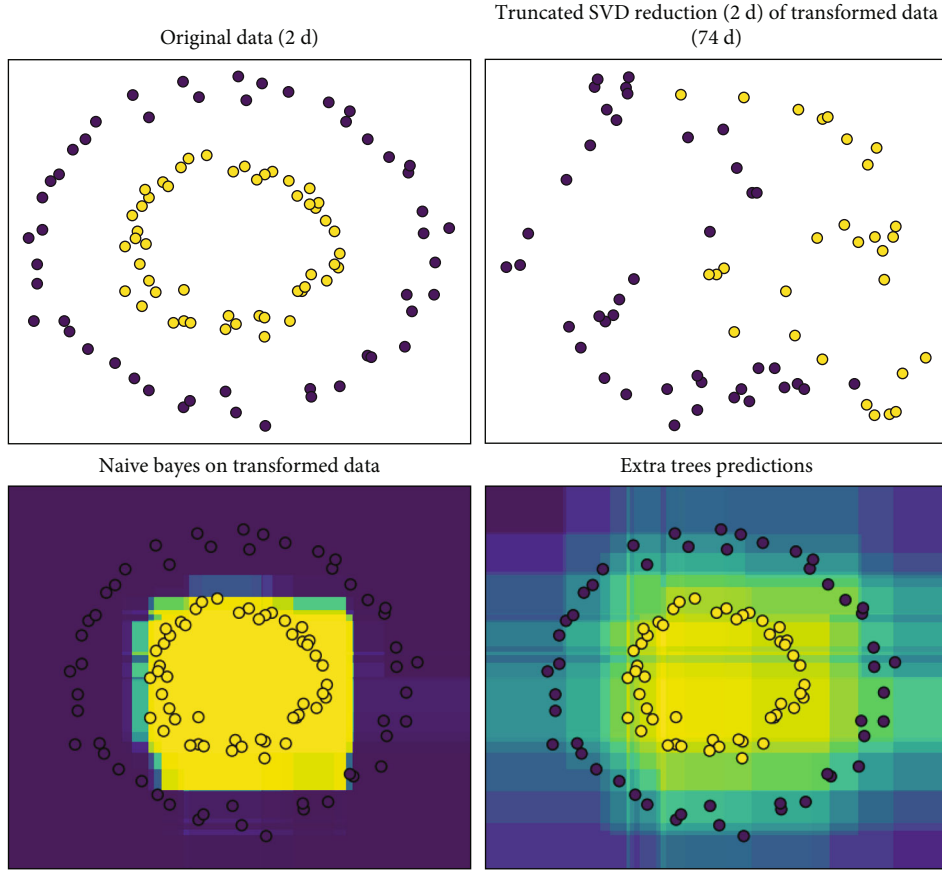
Original data (2 d)

Truncated SVD reduction (2 d) of transformed data
(74 d)

Naive bayes on transformed data

Extra trees predictions

FIGURE 4: Customer-service 2-mode network.

TABLE 4: Analysis of service model centrality.

Serial number	Service name	Degree	NrmDegree	Share
41	Professional substitute services	101.000	23.488	0.138
42	Platform self-service	101.000	23.488	0.138
44	Freemium services	81.000	18.837	0.11
40	Short-term residency service	63.000	14.651	0.086
43	Online Q&A service	21.000	4.884	0.029

and huge matrix into multiple small matrices and then multiplies the decomposed small matrices. For the customer-service 2-mode network data of Pippi Dog, singular value decomposition can help the company to segment customers and discover potential customer relationships and specific service combinations, and for the company's customer relationship maintenance and service quality, service effect. Elevation is of great value. Using the SVD tool in the Ucinet software to calculate the singular values, get the descriptive statistics table of the singular value analysis results in Table 5.

According to the data table of SVD analysis results obtained in Table 5, it can be seen that five singular values are obtained after calculation, and the single percentage of the first singular value reaches 54.3%, which means that the first singular value is very important; the cumulative percentage of the first three singular values reaches 84.6%, so

the first three singular values are more important. See Table 6.

Table 6 is the SVD analysis results of the company's customers. The three most important common factors obtained above are expressed as 1, 2, and 3, respectively. The first common factor accounts for 54.3%. It can be seen from the table:

The projects belonging to the first common factor are "Guangdong Renbo Highway Project Department" (0.399) and "Hebei Xingfen Expressway L3 Project Department" (0.316); the second common factor is "Guizhou Jianrong Expressway Project" (0.236) and "Jingshi Reconstruction and Expansion Project JS6 Project Department" (0.207); the third common factor includes "Luoyang Section Project Department of Yunyang Expressway in Guangdong Province" (0.253) and "Guangzhou Nansha Project" (0.212), etc.

TABLE 5: SVD descriptive statistics.

Factor	Value	Percent	Cum%	Ratio	Pre	Cum Pre
1	33.953	54.3	54.3	3.35	0.669	0.669
2	10.134	16.2	70.4	1.142	0.149	0.818
3	8.874	14.2	84.6	1.671	0.114	0.932
4	5.312	8.5	93.1	1.233	0.041	0.973
5	4.308	6.9	100.00		0.027	1.000
	61.581	100				

From the factor scores of the service model in Table 7, it can be seen that the short-term resident service model has the highest load score on common factor 3 (0.404), indicating that the knowledge service model with the most participation by the "passive" customer group is "short-term resident service"; Professional alternative services and platform self-service models have the highest scores on common factor 1, 0.558 and 0.599, respectively, indicating that the "active" customer group accepts and uses the company's professional alternative services and platform self-service the most; online Q&A service mode The loading scores on the three factors are all low, and there is no obvious clustering tendency, while the free value-added service model has the highest score on the factor 2 (0.497), indicating that the "neglected" customer group uses a larger proportion of free value-added services.

Through singular value analysis (SVD), it can be found that in Pippi Dog's customer-service network, customers are divided into three types: "active", "ignoring", and "passive" (see Table 8). Each of the five service models also has different customer group tendencies under the correspondence of the three factors. Most of the "active" customer groups participate in the company's various knowledge service models and are highly motivated; most of the "ignoring" customer groups do not actively participate in the company's knowledge service activities, and are easily ignored by the company, so passively accept the service The service model is mainly inclined to free value-added services; "passive" customer groups rarely actively participate in the company's knowledge services, but relatively accept more passive services from the company, belonging to "passive", indicating that the company has not ignored Instead of getting rid of these customers, we have provided some specialized services for customers, mainly focusing on "short-term assignment services".

Through singular value analysis, the company can find the correlation between customers and the company's service model, classify customers, and find more suitable services for customer groups, so as to more accurately grasp the status of customers, and adopt different service methods for different groups. Doing accurate service can not only reduce service costs but also accurately meet customer needs and participate in customer satisfaction.

4.3.4. Statistical Analysis of Customer Area Data. By sorting out the number of customers of Pipigo Intelligent Technology Co., Ltd. and the data of the provinces and regions, and with the help of Tableau software, the company's customer distribution map is drawn, as shown in Figure 5. The higher the bar in the figure, the greater the number of customers in the region. Among them, Hebei and Guangdong have the largest number of customers, while Shandong, Henan, Sichuan, Gansu and other places have the smallest number. Heilongjiang, Hunan, and Hubei have not signed contracts for the time being.

Comparing the distribution of the number of customer regions served by Pipdog (Tianjin) Intelligent Technology Co., Ltd. in Figure 5 and the first signing time of each region in Table 9, it can be found that Tianjin, Hebei Province, Henan Province, Shandong Province, and Guangdong Province are the earliest contract customers of the company. The number of customers in Shandong and Henan Provinces is relatively small, indicating that they have not developed new customers on the basis of existing customers after signing customers for the first time until the current statistical time. The number of contracted customers in Guangdong Province and Guangdong Province has grown rapidly, and the company's contracted customers ranked first and second. Among the provinces that did not sign up customers at an early stage, the number of customers in Jiangxi Province came from behind, and it has grown rapidly in the past two years.

By comparing the data of each province's acceptance of and active participation in the company's five types of knowledge services and the data of the number of customers in each province, to find the relationship between services and customer growth, the study found that the number of residency services and the growth of customers in various provinces in recent years. There is a clear connection between the numbers. Table 9 shows the number of customers in each province, the number of dispatched services, and the average number of dispatched services per year.

5. Model Construction and Interpretation

Through the above analysis, the clustering model of customer relationship and service relationship of technology-based small- and medium-sized enterprises is obtained. The model shows the customer behavior relationship and service operation of the enterprise, which helps enterprises to understand customer behavior in depth, use resources more efficiently, and better achieve precise service. Combined with the core paradigms and values obtained by grounded theoretical analysis and summarization, a knowledge service path is created, and a knowledge service model for small- and medium-sized technological enterprises is established from the perspective of value cocreation.

5.1. Relational Clustering Model. In the process of knowledge service activities between enterprises and customers, there is a network relationship between enterprises and customers and between customers. There may be the same type of customer participation between different service modes, and different customer groups are also participating in similar services, which is the underlying link behind the business data that companies tend to ignore. This paper attempts to establish a relationship clustering model by showing the

TABLE 6: SVD analysis factor score table (customer).

	1	2	3
Guangdong Renbo Highway Project Department	0.399	0.093	-0.497
Project Department of Luoyang Section of Yunyang Expressway, Guangdong Province	0.225	-0.172	0.253
Guizhou Jianrong Expressway Project Department	0.138	0.236	-0.248
Jilin Yingsong 8 Bid Project Department	0.024	0.139	-0.194
Construction Engineering Jianxing Project Department	0.150	-0.248	-0.176
Construction Engineering Construction Yongwu Project Section A15 Project Department	0.123	0.132	-0.375
Jingshi Reconstruction and Expansion Project JS6 Project Department	0.176	0.207	-0.145
Nanchang-Ningdu Expressway Nanchang Connection Line N2 Standard Project Department	0.107	-0.232	0.109
Inner Mongolia Pipe Gallery Phase II Project Department	0.093	-0.079	0.163
A7 Project Department of Ning'an Section of Ningdu-Dingnan (Gan-Guangdong) Expressway	0.107	0.218	-0.023
Qinghai Province Gonghe to Yushu Highway Project Department	0.067	-0.147	0.139
Sichuan Renshou Avenue Project Department	0.058	0.125	0.012
Tianjin Binhai Dongting Road Project Department	0.327	0.239	-0.113
......	...	...	...

TABLE 7: SVD analysis factor score table (service).

	1	2	3
Short-term residency service	0.381	0.307	0.404
Professional substitute services	0.558	-0.710	0.004
Platform self-service	0.599	-0.636	0.333
Online Q&A service	0.139	0.099	0.137
Freemium services	0.407	0.497	-0.861

customer-customer clustering relationship and service-service clustering relationship, in order to obtain more valuable analysis results for enterprises through model analysis.

5.1.1. Customer-Customer Clustering Model. The customer-client clustering model is used to understand the potential relationship between the behavior of customers receiving or actively participating in the company's knowledge services by collecting the company's customer behavior data. The customer-client clustering model enables the company's customers to be clustered, and further customer segmentation and customer research can be conducted with the help of the clustering results. The establishment of customer-customer clustering model can deeply dig the implicit relationship between customers and customers, divide customer groups, judge customer service preferences and the status of customer groups, stabilize customers, explore customers, and expand customers, which is conducive to the company's accuracy. The customer-customer relationship clustering model does not have a fixed visual display form. The following is an example of this article.

For example, through the customer-customer 1-mode network structure, use Netdraw to draw a customer-customer network structure diagram, as shown in Figure 6, the denser the connection of the nodes in the figure, the higher the customer centrality represented by the node, and the difference between other customers and other customers. The closer the connection may be, or the higher the similarity, the more potential connections there are,

and the more worthwhile for the company to explore; marginal customers accept or actively participate in the company's knowledge services less frequently and less actively, which is why the company needs to actively develop and maintain its customer base.

The customer-customer network structure diagram (Figure 6) combines the corresponding positions of each node in the scatter diagram (Figure 7) obtained by singular value analysis. After one-to-one correspondence, redraw the new customer-customer network structure diagram, as shown in Figure 7, the company can clearly see the "active" (green/bottom right), "neglect" (blue/bottom left), and "passive" (yellow) based on the visualization of the customer-customer clustering model. Three customer groups understand the characteristics and commonalities of the three customer groups, provide differentiated services for different customer groups, and better improve the quality and efficiency of customer service.

5.1.2. Service-Service Clustering Model. The service-service clustering model is to understand the operation of various service modes of the company by collecting the usage/usage frequency and service effect of various service modes of the company, and the various combinations of mixed usage/usage. Combining the service-service clustering model and the company's own operating costs of various service modes, the company can understand the input-output ratio of various service modes to adjust the company's service focus and better allocate resources. The service-service clustering model aims to clearly show the relationship between service modes, and there is also no fixed display form. The following is an example of this article.

Through the analysis and calculation of the service-service 1-mode network through singular value analysis (SVD), it can be found that among the five service modes, "professional substitute service" and "platform self-service" have the highest frequency of occurrence, and customers accept or actively. The most involved in the two services is the combination of "platform self-service+professional

TABLE 8: Customer classification description table.

| Client	Positive	Neglect	Passive
Serve	Professional alternative services and platform self-service	Freemium services	Short-term residency service
Features	Good service, high satisfaction	Easy to become a lost customer	Easy to develop into neglected customers
Result	Increase in contracted customers in your region/group	The number of customers in the region/group is decreasing year by year	The number of customers in the region/group is basically stable
Measure	Loyal customer development, brand promotion	Mining requirements, with composite services as the main model	Run events to foster online interaction and service engagement
Example	Guangdong area	Henan area	Inner Mongolia region
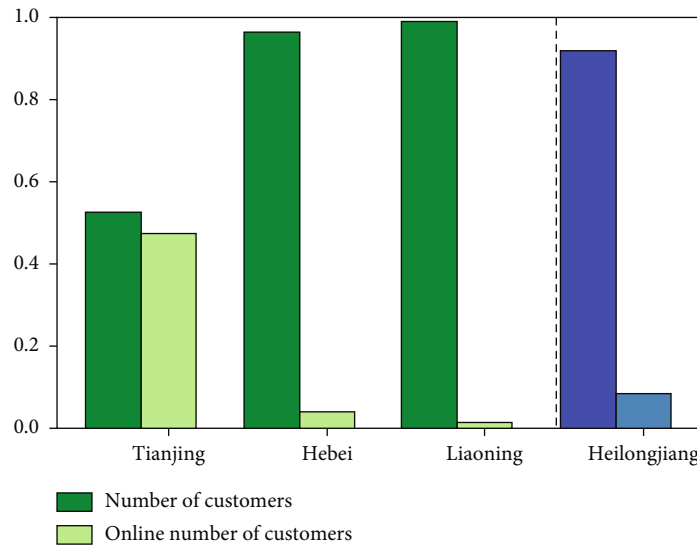
FIGURE 5: Distribution map of the company's customers by region.

TABLE 9: Customer regional distribution and statistical data table.

Area	Number of clients	Residency service	Average number of assignments per year	First contract time
Tianjin	5	25	5.0	2014
Hebei	7	23	3.3	2014
Liaoning	2	3	1.5	2015
Jilin	1	1	1.0	2015
Inner Mongolia	2	5	2.5	2016
Jiangxi	4	13	3.3	2015
Xinjiang	2	6	3.0	2016
Guangdong	6	24	4.0	2014
Qinghai	1	2	2.0	2016
Shanxi	2	5	2.5	2016
Shandong	1	1	1.0	2014
Sichuan	1	2	2.0	2017
Guizhou	2	6	3.0	2017
Tibet	1	2	2.0	2018
Gansu	1	1	1.0	2016
Henan	1	0	0.0	2014

alternative service", which is exactly the same as the node centrality of the two services we mentioned above and the scatter diagram obtained after calculation. In Figure 8, it can also be found that the two services are the closest, and this is also an "online+offline" combination, and the company can use this "online+offline" combination service as the highlight of the company's services.

5.2. Knowledge Service Path from the Perspective of Value Cocreation. According to the code analysis of the grounded theory of the data, it is concluded that the core category of the case is on the premise of value fit, and the technology-based SMEs achieve a win-win value for both parties through the value cocreation process of interacting with customer knowledge services. The service interaction process between technology-based SMEs and customers conforms to the typical paradigm of "condition-strategy-action-result". According to its process, the knowledge service path created by value cocreation can be summarized into three stages: service initiation stage, service implementation stage, and service completion stage.

5.2.1. Service Initiation Stage. In the initial stage of service, customer value demand and enterprise value proposition

Original data (2 d)   Truncated SVD reduction (2 d) of transformed data (70 d)

Navie bayes on transformed data   Extra trees predictions
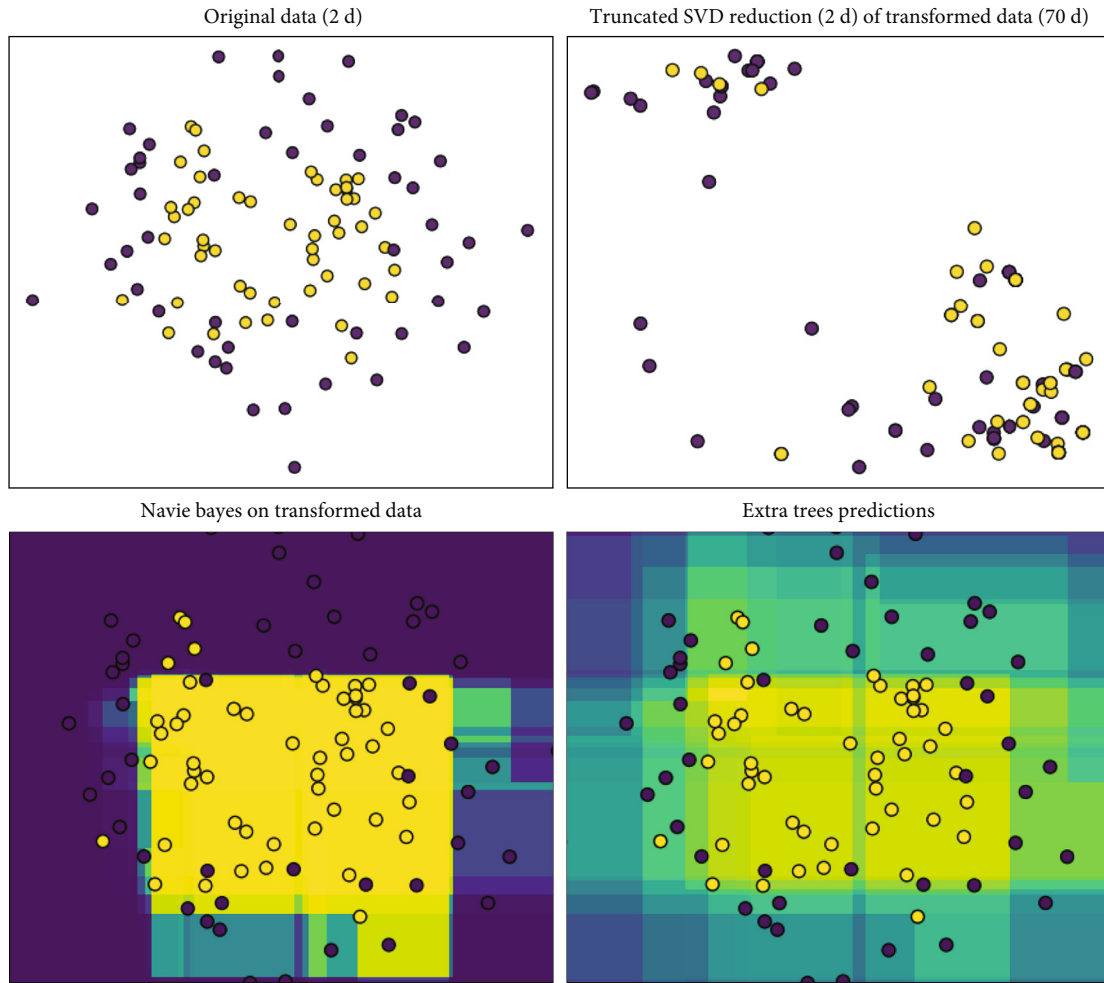
FIGURE 6: Client-client network structure diagram.

need to be agreed, which is the premise and driving force of knowledge service interaction.

When customers have knowledge service needs, they will integrate their own value needs and look for knowledge service companies that can provide services. When the customer finds a service party with the right value, it will send an invitation to it. Similarly, knowledge service companies will continue to look for customers who need knowledge services in the market. Once the first interaction is established between the two parties, multi-directional needs identification and diagnosis begins. In the process of identifying and diagnosing the needs of both parties, enterprises providing services will express their own views, and indicate the scope of skills and services, professional talent teams, etc. Similarly, customers will measure their own value needs while understanding the qualifications and professional conditions of the service provider.

In the process of diagnosing and identifying the needs of both parties, not all enterprises and customers can accurately understand their own needs positioning, and it is impossible to fully diagnose the knowledge and service level of service companies and whether they can fully meet their own value needs. Therefore, in order to achieve the matching of value demand and value proposition, and make the service more

efficient and valuable, both customers and enterprises need to communicate and contact many times, conduct demand management, and negotiate and discuss plans. When necessary, it is necessary to conduct on-the-spot inspections, through a large number of experience exchanges, to clarify their respective needs, to determine service plans, and to lay a solid foundation for follow-up services.

5.2.2. Service Implementation Phase. The service implementation stage is the core stage of the knowledge service interaction process, and the knowledge service implementation process is the process of creating value together between enterprises and customers. In this stage, strategy formulation and interactive realization are the two core links in the service implementation stage.

(1) Strategy Formulation. After the enterprise and the customer reach a value fit in the initial stage of the service, a service implementation plan is formulated. When formulating strategies, enterprises and customers should communicate in a timely manner to ensure the effectiveness of strategies and prevent waste of resources. In order to reach the agreement and achieve the expected effect of the service, the enterprise needs to decompose the tasks one by one according to
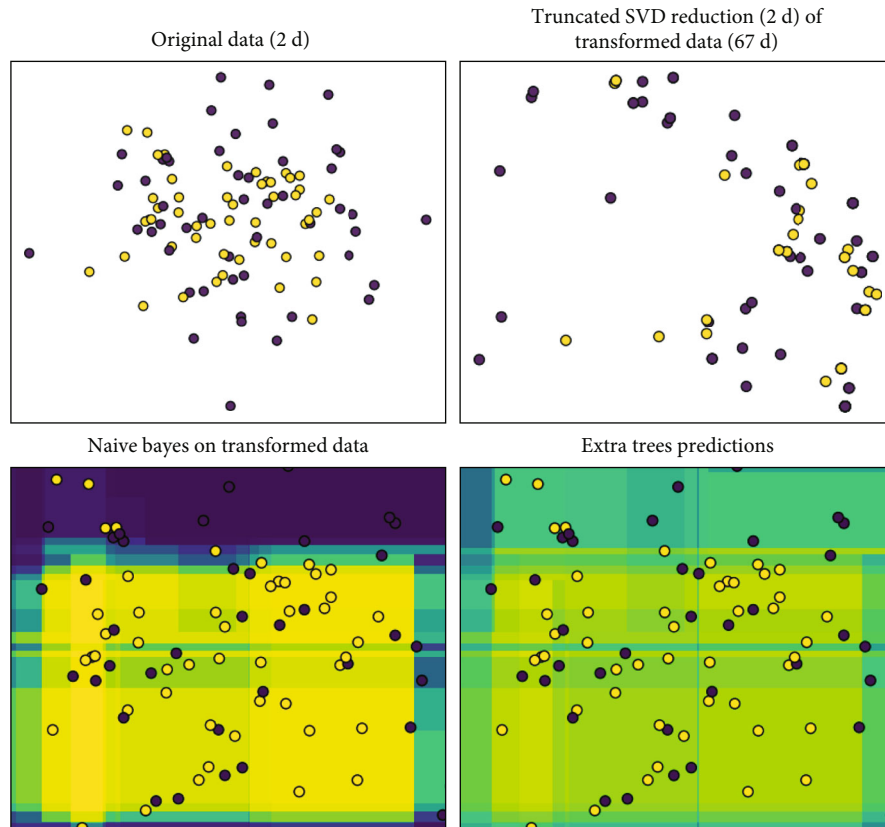
Figure 7: Customer-customer clustering model based on scatter plot.

the customer needs and the agreed content of the service implementation plan. In the process of task decomposition, enterprises can find the difficulty of the task and the bottleneck that needs to be solved urgently. And based on these bottlenecks and difficulties, formulate corresponding strategies to solve the difficulties and break through the bottlenecks, for example, by looking for external professional consultants, increasing R&D investment, etc. Knowledge management within the enterprise and other systems that increase the knowledge stock can also effectively solve customer problems. The details of benefit sharing not agreed in the plan formulated in the first stage should be clarified through negotiation at this stage. In the case of ensuring that the needs of both parties are met, the cost is reduced to ensure the rate of return.

5.2.3. Service Completion Phase. In the service completion stage, through the interaction and in-depth communication between the enterprise and the customer in the service realization stage, various problems agreed in the service plan are solved. On the one hand, it satisfies the knowledge needs of customers. Through the knowledge services provided by enterprises, customers have obtained a large number of heterogeneous resources, breaking through the bottleneck of management and operation, and realizing the improvement of business performance; By absorbing new knowledge and technological innovation, it has improved its own knowledge stock and created new case bases and practical experience. During the service completion stage, there will be evaluation

and feedback modules from both parties. Through the feedback of the company, customers can increase their experience in the value matching stage, speed up the efficiency of value adjustment, and reduce unnecessary costs. Ability to optimize its own service level and efficiency, improve service reputation and brand. Therefore, in the service completion stage, both the enterprise and the customer not only create value together but also improve their knowledge stock and problem-solving ability through talent participation, problem-solving, and technical input in the service interaction process while satisfying their respective value propositions, so that both parties can obtain the improvement of ability and the sublimation of brand value at the same time.

5.3. The Construction of Knowledge Service Model from the Perspective of Value Cocreation. This paper further analyzes the deep relationship between the three stages of the interaction between the knowledge service of technology-based SMEs and customer value cocreation, that is, two-way identification, joint participation, and value win-win, and builds a knowledge service model of value cocreation.

5.3.1. Bidirectional Identification (Premise). In order to provide more efficient services, a consensus between the company and customers is the premise of service. The elements of consensus include first, demand, the company and customers conduct mutual demand diagnosis, the company needs to explore the needs of customers through multiple exchanges, and customers are also communicating. As you
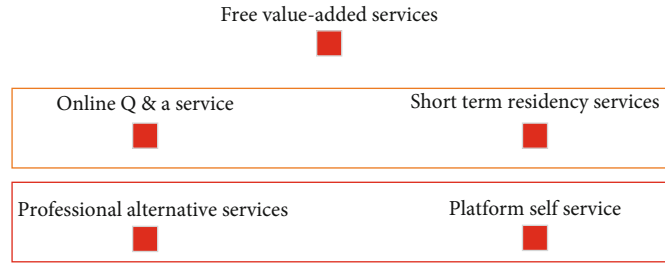
FIGURE 8: Service-service clustering model.

explore, find out what the needs of the company offering the service are. Through two-way demand diagnosis, the company and the customer can increase the tacit understanding in the follow-up cooperation, reduce risks and costs; the second is the plan, the plan formulation and screening are the key elements to reach a consensus, the company based on the customer's initiative demand and company mining. According to customer needs, customized scheme design is carried out. Customers screen and revise schemes based on their own needs and other environmental factors, and companies often adopt multi-scheme presentation methods for the formulation of some key schemes, allowing customers to screen schemes and shorten the time when the plan is finalized; the third is resources. In order to implement the plan efficiently and with high quality, the company needs to integrate the corresponding resources and prepare for the follow-up service. Internally, through the implementation of knowledge management measures, increase the company's relevant knowledge stock. Externally, through knowledge exchange with the outside world and the customer's own resources, the knowledge stock is increased; the fourth is value, the company estimates the available income through cost accounting, income estimation and other methods to weigh the pricing and other benefit models. For example, in the contract, increase the 5% profit share after the project is completed, and the customer will also compare and weigh according to the company's quotation and the value created, and the two parties will adjust the value matching and reach an agreement.

5.3.2. Joint Participation (Conditions). Under the leadership of different logics, both the company and its customers participate in the service together, and in the Investing knowledge and resources in the process is the premise of the value cocreation theory. The interactive activities between enterprises and customers are positively related to the value creation of the two. The more interactive activities they participate in, the greater their customer stickiness. This study found that Pippi Dog provides five knowledge service modes for customers: platform Q&A service, short-term dispatch service, self-service inquiry service, professional substitute service, and free value-added service. In order to allow customers to better participate in knowledge services, the company has designed five service models, including "online +online" channels and "active+passive" service operations. The development of each service model requires the joint participation of the company and customers, and the level of joint participation directly affects the effect of knowledge

services. Customers have their own priorities and preferences, and they will provide and support their own resources in one or several knowledge services. Through joint participation, in the process of interaction between the company and customers, obtain the necessary knowledge, meet its own needs and give feedback to optimize knowledge services, so as to obtain better service experience and knowledge creation. As shown in Figure 9.

5.3.3. Value Win-Win (Target). The process of knowledge service is the process of value cocreation. It is found that there are four win-win situations in the process of providing knowledge services to customers. First, in the process of dealing with various affairs and problems of customers, in order to better meet the needs of customers, through the learning of relevant skills and the reserve of relevant knowledge, small- and medium-sized technology-based SMEs improve their knowledge reserve and increase their practical ability (accumulation of process experience). Secondly, both enterprises and customers meet their needs after completing knowledge service activities (needs are satisfied); thirdly, with the improvement of management and innovation capabilities of customers and enterprises, both parties' operational efficiency is improved (operational performance is improved); fourthly, with the help of customers through knowledge services and continuous enrichment of their own experience, product market scale is expanded and brand value is increased, and enterprises also gain the reputation of customers, and the brand value has been enhanced, and more customers have been signed (brand value sublimation). In the value win-win stage, after the completion of the knowledge service project, the enterprise and the customer should not only meet their respective needs and goals but also pay special attention to the knowledge management and mutual review and exchange between the enterprise and the customer, and do a good job in the management of cases and experience and knowledge sharing, in order to better realize the value and win-win situation.

5.3.4. Knowledge Service Model from the Perspective of Value Cocreation. Through the case study of Tianjin Pipigou Intelligent Technology Co., Ltd. providing knowledge services to 39 customers, it analyzes the company's various first-hand and second-hand materials, coded materials and continuously compares them, and explores the relationship between the company and customers through social network analysis. Relationship, have a deeper understanding of the categories and orientations obtained from the previous coding,
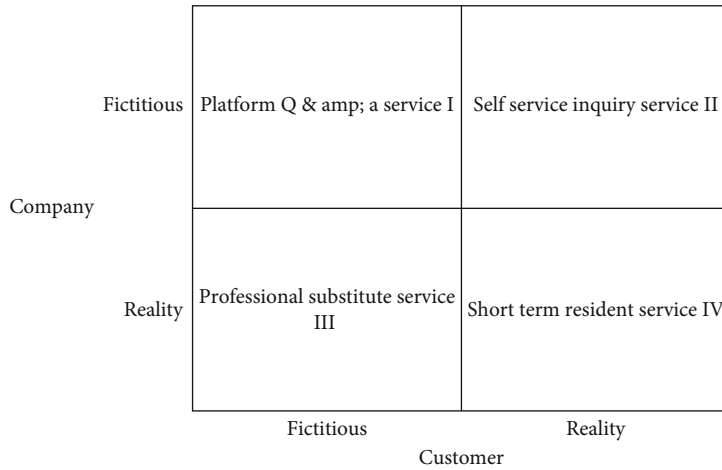
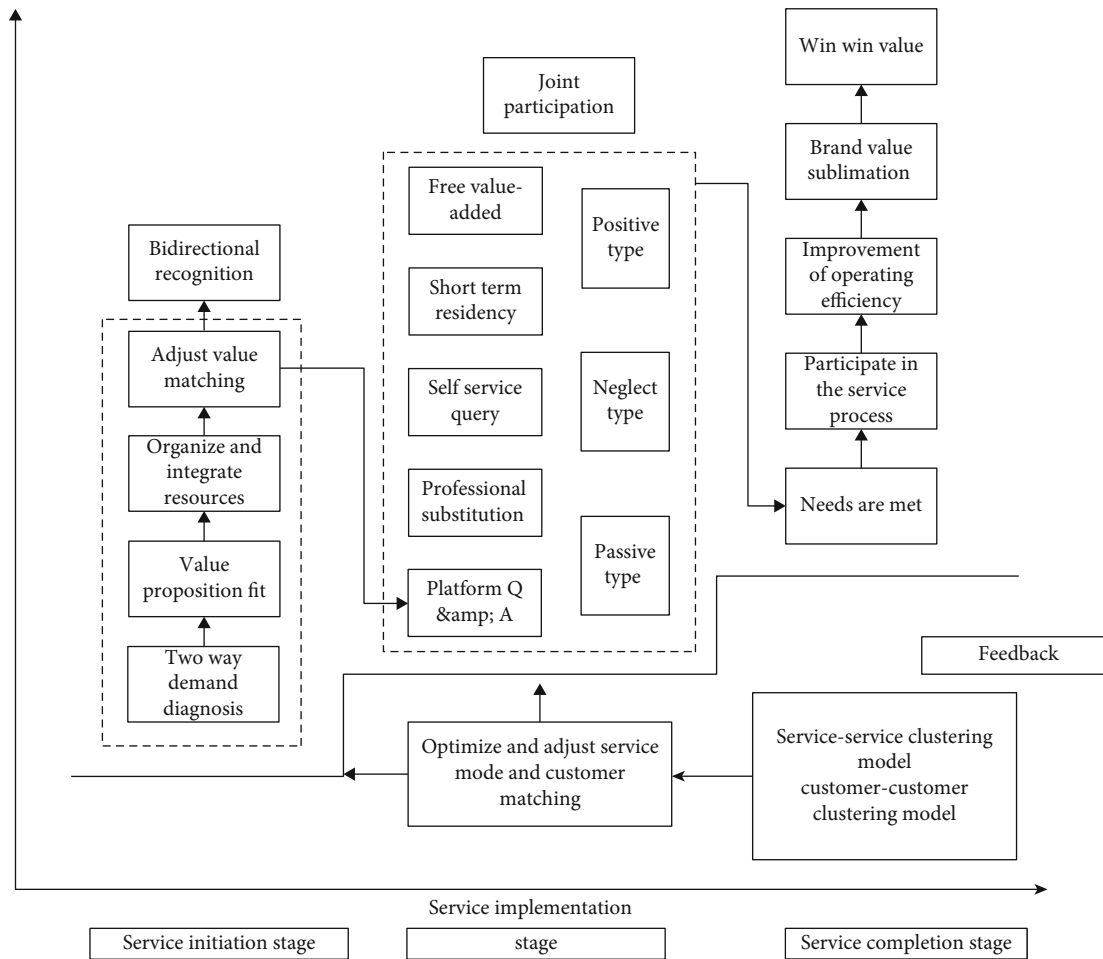Figure 9: Service interaction analysis diagram.

Figure 10: Cocreation model of knowledge service value for technology-based SMEs.

build the logical relationship between the main categories and the knowledge service path created by the value, and combine the social network analysis of customers and service models. Relational clustering model", thus constructing a knowledge service model from the perspective of value cocreation, as shown in Figure 10. The study found that

from the perspective of value cocreation, there are three stages in the knowledge service process of technology-based SMEs to customers: "service initial stage (consensus)-service implementation stage (service)-service completion stage (win-win)", The three stages correspond to the knowledge service model of "two-way identification-joint

participation-value win-win". Two-way identification is the value consensus between the company and customers, and is the premise of knowledge service; joint participation is a necessary condition for the company and customers to carry out knowledge services from the perspective of value cocreation; value win-win is the last stage of the knowledge service model. Obtaining a win-win situation is the goal of developing knowledge services. The whole process of the knowledge service displayed by the model is interlinked, and each stage is constantly sublimated. After the project is completed, through the analysis and overthrow of the project data, the service-service clustering model and customer-customer clustering model can be established. It enables enterprises to have a clearer understanding of the current situation of their knowledge services and the potential connection of customers before, and feed the results back to the optimization and adjustment of the service model, so that the services can be accurately matched with customers, thus continuously optimizing the service model and continuously reducing the service cost. See Figure 10.

6. Conclusion

Transitioning from the "preknowledge service era" to the "postknowledge service era", the postknowledge service era has promoted the transformation of knowledge service from the combination of technology and humanities, multidisciplinary intersection and intelligence. The subjects and objects of knowledge services are also undergoing great changes. How do science and technology-based SMEs provide knowledge services to their customers? How can technology-based SMEs and the customers they serve achieve value cocreation? Most of the studies in the existing literature focus on knowledge services provided by knowledge service institutions or various libraries for enterprises, but there is a lack of in-depth research on this issue. In this paper, we adopt a hybrid research approach to analyze the collected data from multiple perspectives in three dimensions, to explore the correlation behind the data and to construct a knowledge service model.

In this paper, the three dimensions (time, content, and space) of the case company data are analyzed and combined in the research process. In the time dimension (T), the time series analysis method is used to study the time of technology-based SMEs serving customers. Through the contract ledger and other data, the annual growth trend graph of the company's contracted customers and the annual trend graph of the number of business trips served by the company's dispatched employees were established. By comparing the changes of annual curves with the comparative graphs of the number of resident services and the number of new additions in the company's region in the social network analysis section of the spatial dimension (S), it is found that the number of resident services directly affects the number of regional customers contracted. In the content dimension (C), grounded theory was used as the research tool to code the collected raw data through grounded theory. The main classification is "knowledge service model for technology-based SMEs". In the spatial dimension (S), the centrality and singular values of the

company-customer bimodal social network structure were analyzed with the help of five business models of corporate services coded in the content dimension (C) using Ucinet software. It was found that company and customer participation in knowledge services is relatively concentrated in platform self-service and professional alternative services, which are also combined online and offline models and produce greater results, while customer participation in platform Q&A services is low. Resources are not effectively utilized and the service effect is poor; meanwhile, after analyzing customer behavior, it is found that the company's customers can be divided into three types: active, neglected, and passive, which helps the company to classify and differentiate customers. Services provided, using the characteristics of different service models to precisely serve different types of customers; through company-customer bimodal social network analysis and time series analysis, it complements the interactive relationship and services between the company and customers involved in knowledge services from the perspective of value cocreation. In this way, the knowledge service model from the perspective of value cocreation is constructed, which gives reasonable management for customer classification and precise services of technology-based SMEs suggestions, which is conducive to more efficient and accurate knowledge services of the company.

With a series of national policies to support their rapid development, technology-based SMEs continue to be the power engine and key to the development of innovative economy. In the background of knowledge economy, the transformation of production factors and the development of Internet communication technology have forced technology-based SMEs to transform and reform. Professional knowledge services can not only provide incremental knowledge for enterprises themselves and expand their intellectual capital but also make professional knowledge services part of the company's business to meet customers' knowledge needs. Knowledge services may become an important direction for the transformation and development of technology-based SMEs.

This study still lacks in-depth research on the specific effect of value cocreation and service feedback between technology-based small- and medium-sized manufacturing enterprises and their service customers and does not build a more detailed knowledge service model nor does it establish a service evaluation and feedback system and does not make the knowledge service model form a closed loop to achieve service renewal and iteration.

Data Availability

The experimental data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declared that they have no conflicts of interest regarding this work.

Authors' Contributions

Dongliang Sun and Wei Yao are co-first authors.

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