Benefit distribution and stability analysis of enterprise digital servitization ecosystem from the perspective of value co-creation

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Abstract: Digital servitization ecosystem (DES) is a cooperative model based on the concept of value co-creation. However, asymmetries in capabilities between enterprises in this ecosystem can lead to unfair benefits distribution, hindering value co-creation and digital servitization transformation. This paper revises the benefits distribution based on the influencing ability factors of the digital servitization transformation to build the benefit model of enterprise digital servitization cooperation. Using coalitional game theory, we propose a benefit distribution mechanism that can maintain stable cooperation of DSE enterprises. The results show that the benefit distribution of enterprises in DSE is significantly affected by investment contribution ability, digital servitization level, brand-ability. Moreover, Shapley value enhances the cooperation between enterprises in DSE. It promotes the stable development and the value co-creation among members. This study provides a new direction for the stable development of DSE enterprises.

Keywords: digital servitization; ecosystem; value co-creation; coalitional game; shapley value

1. Introduction

With the application of digital technology, the provision of complex and novel services is promoted, and the servitization is further developed. The integration of digitalization and servitization promotes the digital servitization transformation of enterprise (Dalenogare et al. 2023). The emergence of digital servitization has pointed out a new direction for enterprises to realize business model innovation and ecosystem construction. It expanded the scope of traditional value chains, and provided unprecedented opportunities for enterprises to achieve more value co-creation (Manser Payne, Dahl, and Peltier 2021; Kolagar, Parida, and Sjödin 2022). However, enterprises need to master product capabilities, service capabilities and other capabilities related to digital technology to realize digital servitization. And it is difficult for a single enterprise to manage so many capabilities set, which requires the complementary capabilities of multiple enterprises (Marcon et al. 2022). Therefore, many enterprises participate in the digital servitization ecosystem (DES), sharing resources and integrating technologies to jointly develop and provide innovative digital services to achieve value added of value chain (Dalenogare et al. 2022). For example, KONE established an ecosystem partnership with IBM, launched an elevator remote monitoring service based on IBM Watson. KONE and IBM took a new step in value co-creation by shifting from passive maintenance to active maintenance with the power of the Internet of Things (Marcon et al. 2022). Thus, as Dalenogare et al. (2023) report, DSE is becoming an important way to realize value co-creation in the process of digital servitization.

However, cooperation in DSE will bring certain threats to each other due to the profit-driven and competitive relationship of enterprises (Wang, Wang, and Mardani 2023). In particular, different enterprises in DSE have increased the difficulty of data integration and inhibited value co-creation due to the heterogeneity of data and the inconsistency of data formats. For example, Google cooperates with smart home company Nest to develop a smart home ecosystem. The functions and user experience of the smart home system are limited due to the incompatibility of data formats and protocols (Struckell et al. 2021). In addition, enterprises are not convinced of egalitarianism in DSE due to their different capabilities, thus falling into the 'free rider' effect. While value distribution is generated based on the creation of different links in the value chain, it is difficult to achieve complete trust in the process of value co-creation (Jacobides, Cennamo, and Gawer 2018), and a new value mechanism is needed to coordinate all subjects within the system. For example, China's Alibaba and JD.com planned to integrate their respective DSEs, but the two sides disagreed on the allocation of value during the cooperation process, which ultimately led to the breakdown of the cooperation (Hänninen, Mitronen, and Kwan 2019). Therefore, how DSE enterprises achieve value co-creation, and how to fairly distribute these values among ecosystem participants remains a complex and challenging practical problem.

The research of DSE mainly focuses on the construction mode, capability needs and data resource sharing. Among them, value creation is the core motivation and goal of the ecosystem (Dalenogare et al. 2023). However, the distribution after value creation and the factors that need to be taken into account in the distribution remain largely unexplored. Research on value distribution mainly focuses on innovation alliances and value chains (e.g., Wang, Zhao, and Baležentis 2023; Arslan 2018), especially the study on the benefit distribution mechanism of technological innovation (Jiang et al. 2021) and product innovation (Arora, Belenzon, and Patacconi 2021) mainly considers the influence of investment contribution and cooperation degree. And the factors affecting enterprise digital servitization come from many aspects inside and outside the value chain (Dalenogare et al. 2023). Traditional value distribution mechanism (such as revenue sharing model) is no longer suitable for the complex and diverse enterprise interest relationships in DSE. How to distribute the created value in DSE and how to construct the distribution mechanism considering the special influencing factors of these DSEs need further research. If enterprises in DSE still follow the existing distribution methods, value co-creation will not be realized, and even the stable development of DSE will be seriously affected (Pathak, Ashok, and Tan 2020). Therefore, exploring the stable development of DSE on the basis of the traditional value chain is an important issue to be studied.

Therefore, the main purpose of this paper is to build a suitable benefit distribution mechanism of DSE to adapt to the new competitive environment. By introducing correction factors, we modify the benefit distribution of enterprises in DSE, and explore the benefit distribution under the correction factors, to achieve the fair development and lasting operation of DSE. Through numerical analysis, the key capabilities that affect enterprise digital servitization are illustrated. The results show that in addition to investment contribution, digital servitization level, brand and digital level capability are the key factors affecting digital servitization. These are the latest in the literature of using models to address issues related to DSEs.

The contribution of this paper has the following aspects. First of all, we discuss the digital servitization of enterprises from the perspective of value co-creation, focusing on the digital servitization transformation of ecosystem enterprises with complementary value chain capabilities. When exploring enterprise cooperation in DSE, the significant influence of digital servitization level is determined, which provides new ideas for alleviating the 'free rider' effect of enterprise digital servitization cooperation. Secondly, this paper determines the benefit distribution correction factors of enterprises in the DSE, and provides contributions and supplements to the literature on digital servitization. Most of the existing literature studies the ecosystem construction and business model transformation of digital servitization from an empirical perspective. In this study, we determine correction factors based on the value chain to design the benefit distribution mechanism, analyze the benefit distribution of enterprises in the DSE of enterprises, and provide a new perspective for the literature on digital servitization from a quantitative perspective. Third, we have determined the benefit distribution mechanism of enterprises participating in the DSE, which can make the stable development of the DSE. We propose a Shapley value benefit distribution mechanism, which can satisfy the core of coalitional game, so that enterprises can benefit from the DSE and realize value co-creation in the process of digital servitization.

The rest of this paper is arranged as follows: Section 2 reviews the relevant literature. In Section 3, we describe the problem and make some assumptions. In Section 4, the traditional Shapley value model and the modified Shapley model are established to determine the distribution mechanism. Section 5 provides a numerical analysis to illustrate the theoretical results. The conclusion and prospect are given in Section 6.

2. Literature review

In this section, we review previous research on digital servitization, digital servitization ecosystems, and the benefits distribution in innovation alliances, as summarized below.

2.1. Digital servitization

The concept of 'servitization' was first put forward by Vandermerwe and Rada (1988). Manufacturing enterprises have changed their market strategy from providing products to services (Peng et al. 2023; Zeynivand et al. 2021). For example, General Electric and Nokia have transformed from traditional product manufacturers to integrated solution providers based on product portfolio and full life cycle services. At the same time, the manufacturing digital business model began to emerge. Enterprises based on digital technology provide customers with intelligent product-service systems to reduce costs, improve internal efficiency and promote the company's service orientation. Digitalization is increasingly seen as an enabler and driver of servitization business models, value creation and value capture (Peng, Chen, and Lee 2023; Liu et al. 2022). Digitalization is both a driver and enabler of servitization (Gaiardelli et al. 2021; Liu et al. 2022).

Digital servitization is defined as the organic integration of digitization and servitization (Gaiardelli et al. 2021; Paschou et al. 2020). Through the application of digital technology to provide complex and novel services to further promote the service

(Gaiardelli et al. 2021; Paschou et al. 2020), and to provide more efficient digital solutions to meet customer needs at the same time (Liu et al. 2023; Gebauer et al. 2021). Because digital technologies (such as cloud computing, big data, artificial intelligence, Internet of Things, etc.) provide support and infrastructure for various service providers and consumers, driving innovation and development of digitalization and servitization (Paschou et al. 2020). With the help of information technology and Internet technology, enterprises can more effectively identify customer demand data to achieve a more favorable digital service (Dou et al. 2021). Digital technology stimulates the provision of smart products, servitization, and creates service value. The development of digital servitization requires a complex system of interconnected capabilities, which is difficult to achieve with a single enterprise (Manresa, Prester, and Bikfalvi 2021). Because the complexity of intelligent solutions requires the integration of software, hardware, networks and services, these integrations exceed the capabilities of a single enterprise and need to be integrated into an ecosystem.

The definition and transformation process of digital servitization was mainly studied, with a focus on exploring the perspectives of manufacturing enterprises, service provider and customers. The current research focuses on the challenges and transformation paths faced by digital servitization enterprises, laying a theoretical foundation for them to enter digital servitization. However, few studies have focused on the distribution of benefits in DSE through the perspective of multi-agent cooperation during the transformation of digital servitization.

2.2. Digital servitization ecosystems

Enterprise cooperation in DSE is related to the combination of resources and capabilities. Through value creation and value acquisition, the business model objectives and enterprise interactions of the ecosystem can be described (Dalenogare et al. 2023). The interaction between the enterprises in DSE, such as manufacturing enterprises, service enterprises, technology providers, etc., is very complex. For example, developing integrated solutions requires multi-source sharing of customer data, which requires a high level of trust within the ecosystem (Dalenogare et al. 2023). When developing autonomous driving, Tesla, Rolls-Royce and other companies need to rely on the product-service-software system interaction of multiple enterprises to achieve intelligent autonomy, that is, cross-border cooperation.

Digital servitization requires organizations to align ecosystem complementors through a range of capabilities to translate the potential value of digital servitization into revenue streams (Dalenogare et al. 2023; Marcon et al. 2022). Especially with the help of digital technology, enterprises promote value co-creation in the process of digital servitization, change the resource integration model, and ultimately change the service ecosystem (Dalenogare et al. 2022). General Electric, for example, has launched a digital platform called 'Predix' that can remotely monitor and control industrial equipment. Through the integration of digital technologies and service providers in DSE, so that innovative, high-value digital services can be generated and provided to provide users with more convenient, more efficient and better service experience (Dalenogare et al. 2023).

The research on DSE mainly focuses on the ways and capabilities of ecosystem implementation, data resource sharing and so on. Few studies have focused on the impact of firms' participation in DES on benefit distribution. Our research is faced with the fact that internal and external factors have a common impact on enterprise digital servitization cooperation. By confirming the proportion of these influencing factors on benefit, we can improve the distribution mechanism and provide a new idea for enterprise digital servitization cooperation to avoid the 'free rider' effect.

2.3. Benefits distribution in innovation alliances

Due to the objective differences between members in capital investment, innovation ability, scientific research scale, etc., the benefits distribution is usually biased. This bias can affect relationships between businesses and can harm the entire network (Liu and Papageorgiou 2018). The alliance formed by enterprise cooperation is often difficult to survive because of the imbalance of benefit distribution, and the fairness of benefit distribution will also affect the stability of the inter-organizational alliance (Huang et al. 2021). The main factors that affect the stability of the alliance are benefit distribution, innovation spillover and knowledge spillover (Arora, Belenzon, and Patacconi 2021).

As an allocation method in coalitional game theory, Shapley value is more concise and effective than other coalitional game allocation methods (Leng, Luo, and Liang 2021). The increase in Shapley value significantly enhances multi-party cooperation and can be used as an effective tool for a fair and reasonable allocation (Wang, Wang, and Mardani 2023). Aiming at the stability of technological innovation cooperation alliances formed by multiple enterprises, Jiang et al. (2021) proposed a benefit distribution mechanism that can maintain stable cooperative relationships based on the number of resources invested by enterprises in technological innovation cooperation alliances. Wang, Zhao, and Baležentis (2023) studied the benefit distribution of private charging piles under the sharing economy and established the modified Shapley value method based on the cloud gravity center to fairly distribute the benefits generated by private charging pile sharing, which is an effective tool for a fair and reasonable allocation of private charging pile sharing projects.

Although the Shapley value method can avoid the average distribution among various entities in the supply chain, it only considers the contribution of each entity to the supply chain benefit distribution, ignoring the influence of other factors. Taking this as an extension, this study considers the impact of enterprises' investment contribution ability, digital servitization level, digitalization level, risk-taking ability, digital servitization effort, and brand-ability on their benefits, analyzes the impact of each factor and determines important indicators. It can guide the benefit distribution of enterprises' digital servitization cooperation in reality.

2.4. Literature comment

To sum up, enterprises in DSE not only need to cooperate when they transform with digital technology to achieve value co-creation but also need to pay attention to avoid falling into 'free rider' utility in the cooperation process. Previous studies tend to focus on the capabilities and business model construction required for cooperation in DSE. Our research allows us to realize what factors affect collaboration in digital servitization and to what extent.

By modifying the Shapley value method, we can provide a benefit distribution mechanism for DSE enterprises' collaboration and mitigate the 'free rider' effect. Our research results highlight the impact of enterprises' investment contribution ability, digital servitization level, digitalization level, risk-taking ability, digital servitization effort, and brand-ability on the benefit distribution of DSE, and provide a distribution mechanism for the competition and cooperation of digital servitization enterprises, so as to promote the transformation process of digital servitization enterprises. In addition, we highlight the investment contribution capacity, digital servitization level and digitalization level that have a significant impact on the DSE enterprise. Then we analyze the different effects of their changes on benefit. The findings will contribute to a better understanding of the dynamics of DSEs and provide insights into how businesses can effectively manage and benefits distribute generated within these ecosystems. Table 1 provides a brief comparison of the above relevant studies with our work.

Table 1. Brief comparison of relevant papers.

References	Digital servitization	Ecosystem	Capabilities	Benefit distribution
Paschou et al. (2020)	√		√	
Gebauer et al. (2021)	√		√	
Manresa, Prester, and Bikfalvi (2021)	√	√	√	
Dalenogare et al. (2023)	√	√	√	
Kolagar, Parida, and Sjödin (2022)	√	√	√	
Wang, Zhao, and Baležentis (2023)		√	√	
Marcon et al. (2022)	√		√	
Liu and Papageorgiou (2018)				√
Kokkonen et al. (2023)		√	√	
Our work	√	√	√	√

3. Problem description and assumptions

3.1. Problem description

In this paper, we consider $n \geq 2$ DSE enterprises that collectively invest their resources, share customer data, digital technologies, and product technologies to enable digital servitization as they transform. The DSE includes manufacturers, service providers, data providers, customers, etc. We will establish a benefit distribution mechanism for DSE enterprises to judge the impact of benefit output under different correction factors.

The OpenPower Alliance, for example, was formed by companies such as IBM and Google. OpenPower Alliance is expanding and improving the application domain and performance benchmarks of the POWER architecture through a series of innovations in hardware, firmware, middleware, operating systems, and application layers by its partners. It also provides enterprise users with an efficient platform for diverse workloads such as cloud computing, big data analytics, high-performance computing and artificial intelligence. Figure 1. depicts the framework of benefit distribution of DSE enterprises.

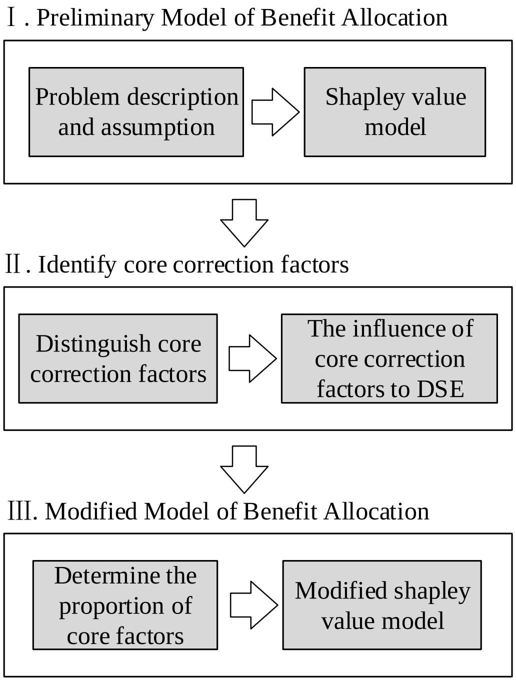

Figure 1. Benefit distribution framework of DSE enterprises.

In the process of digital servitization transformation, considering that the digital service is non-proprietary and easy to be imitated by competitors, we use the brand awareness to quantify the degree of imitative difficulty of digital services. Taking into account consumer psychology, the more the corporate brand identity is recognized, the more consumers will trust the service business of the product company, which can have a key impact on digital service competition (Alnawas and Hemsley-Brown 2019). Table 2 shows the symbolic description of this study.

Table 2. Parameters related to the paper.

Abbreviation	**Description**
DSE	Digital servitization ecosystem
IC	The investment contribution of enterprises
RT	The risk-taking capacity of enterprises
DSL	The digital servitization level of enterprises
DSIE	The digital servitization innovation effort of enterprises
BA	The brand awareness capacity of enterprises
DL	The digitalization level of enterprises
Parameters	**Description**
n	The set of enterprises

s	The DSE formed by enterprises
φ_i	Benefit allocated by enterprise i
i_i	The total value of enterprise i investing in DSEs
r_i	Digital servitization's risk-taking ability of enterprise i
s_i	The digital servitization level of enterprise i
e_i	The digital servitization innovation effort of enterprise i
b_i	The brand awareness capacity of enterprise i
I	Investment contribution capability factor
R	Risk-taking capacity factor
S	Digital servitization level factor
D	Digitization level factor
E	Digital servitization innovation effort factor
B	Brand awareness capability factor
$v(s)$	Benefits of a DSE s
$w(\|s\|)$	The probability of enterprise i adopting cooperation to enter the DSE s

3.2. Model assumptions

To make the results of the current article more reasonable, we assume the following exists.

Assumption 1. Referring to Jiang et al. (2021), we assume that the enterprise resource information within DSE is public, that is, the information of enterprises within DSE is symmetric.

Assumption 2. Based on Arslan's (2018) study on alliance member cooperation, we assume that when enterprises collaborate within a DSE, each participant voluntarily participates in the cooperation only if the benefits distribution through cooperation is higher than the benefits obtained through independent digital servitization transformation.

Assumption 3. The cost of digital servitization investment remains unchanged during the cooperation period, as assumed by Jiang et al. (2021) when enterprises conduct digital servitization transformation alone and cooperates for digital servitization transformation.

Assumption 4. Assuming that digital services have a similar overall impact on the sales of products of members of the DSE when enterprises provide digital services (Liu, Ji, and Ji 2022), the benefit of the service sector mainly affects its distribution.

4. Model

4.1. Traditional Shapley value model

The Shapley value model is a classic benefits distribution method for solving multiperson coalitional games. It mainly uses logical modeling to study the benefits distribution of members' contributions to collective benefits. It is the application of coalitional game equilibrium. With the help of Shapley value model, we propose the DSE as a kind of innovation alliance (Kokkonen et al. 2023). Suppose that a supply chain involving n enterprises need to complete an activity, and each enterprise can gain certain profits by competing in the market. To achieve a common goal, however, a DSE s has been formed. In the process of cooperation, each node enterprise should reorganize and optimize various resources, knowledge, technology, etc., to increase the value of the supply chain. Then, the benefits that enterprise i can share from the total benefits in the DSE s is expressed as:

$$\varphi_i = \sum_{S \in S_i} w(|s|)[v(s) - v(s \setminus i)], i = 1, 2 \tag{1}$$

$$w(|s|) = \frac{(n - |s|)!(|s| - 1)!}{n!} \tag{2}$$

Where $|s|$ is the number of elements s in itself; $v(s)$ describes the benefits of the DSE s; s_i represents all subsets included i; $[v(s) - v(s \setminus i)]$ represents the contribution of i cooperation s $(i \in s)$; $w(|s|)$ represents the probability that the enterprise i adopts cooperation to enter DSE s, and meets $\sum \varphi_i = v(I)$, $\varphi_i = v(i), i = 1, 2$.

Because the Shapley value method is based on the contribution of individual investment to the cooperation alliance and participates in the benefits distribution, many scholars modify the model by introducing risk factors, information value factors, etc.. Therefore, this paper introduces the correction index to revise the benefits distribution results.

4.2. Correction index identification

Referring to relevant scholars' research on digital servitization (Dalenogare et al. 2023; Dalenogare et al. 2022; Kolagar, Parida, and Sjödin 2022), the risk of enterprise digital servitization cooperation mainly includes six factors: investment contribution ability (IC), digital servitization level (DSL), digitalization level (DL), risk-taking ability (RT), digital servitization effort (DSE) and brand awareness capability (BA). Considering the above factors, the traditional Shapley value model was modified by constructing correction factors.

4.2.1. Investment contribution ability (IC)

In the cooperation process, the DSE enterprises may indulge in the free-rider effect, thus violating the original intention of reducing costs. Free-rider behavior results in a fragile cooperation relationship among enterprises and makes the cooperation not conducive to the improvement of enterprise benefits and performance. Therefore, fixed capital investment, personnel investment, capital source investment and knowledge investment are taken as investment indicators to determine the investment contribution of each enterprise in the DSE.

Assuming that k_{id} represents the amount of digital servitization d invested by DSE member i, and total value i_i of enterprise i investment in DSE can be expressed as:

$$i_i = \sum_{d=1}^{n} h_{id} \tag{3}$$

Normalize the obtained investment in DSE of enterprises, and guarantee formula (4) is established:

$$\sum_{i=1}^{n} i_i = 1 \tag{4}$$

4.2.2. Risk-taking ability (RT)

The enterprises in DSE are a coopetition relationship, and there is cooperation risk. Therefore, this paper takes management risk, resource integration risk, information and technology sharing risk as risk indicators. Quantify the risk-taking capacity of members in DSE through expert scoring, and get the following after normalization:

$$\sum_{i=1}^{n} r_i = 1 \tag{5}$$

4.2.3. Digital servitization level (DSL)

According to the method of cooperation contract, the digital service business ratio, digital service investment ratio and digital service investment rate of DSE members in the contract period are taken as quantitative indicators to analyze the digital servitization level of enterprises. Finally, the obtained enterprise digital servitization level is normalized, and the guarantee formula (6) is established

$$\sum_{i=1}^{n} s_i = 1 \tag{6}$$

Where s_i indicates the digital servitization level of enterprise i.

4.2.4. Digital servitization effort (DSE)

According to the method of cooperation contract, the effort of participating in digital servitization is evaluated by a third party. Then, the obtained effort index is normalized, and the guarantee formula (7) is established.

$$\sum_{i=1}^{n} e_i = 1 \tag{7}$$

Where e_i indicates the digital servitization efforts of enterprise i.

4.2.5. Digitalization level (DL)

According to the digital business ratio, digital analysis investment ratio and digital return on investment of each member in the cooperation cycle of DSE, the digitalization level of the enterprise is analyzed. Finally, the obtained enterprise digitization level is normalized to ensure that formula (8) is established

$$\sum_{i=1}^{n} d_i = 1 \tag{8}$$

Where d_i indicates the digitalization efforts of enterprise i.

4.2.6. Brand awareness capability (BA)

Although the enterprises have formed a DSE and become a community of interests, the goal among members is to maximize interests. Considering the ease of imitation of service, enterprises need a strong enough brand ability to resist the imitation competition among peers so that consumers have the mentality of brand recognition, making it difficult to replace the brand (Alnawas and Hemsley-Brown 2019). Brand ability can be reflected in market share; that is, the higher the market share, the more market opportunities can be grasped. According to the principle of consistency between benefits and contributions, the market share factor (Herfindahl-Hirschman index), widely used to measure market share in market economics, is used for reference. Because there is a direct relationship between brand awareness and market share, this index can be used for characterization. Assuming that the member i's brand awareness is b_i, and there is a final normalization of the enterprise market share index, the guarantee formula (9) is established.

$$\sum_{i=1}^{n} b_i = 1 \qquad (9)$$

Then, the specific relevant indicators of the correction factor for manufacturing enterprise are shown in Figure 2.

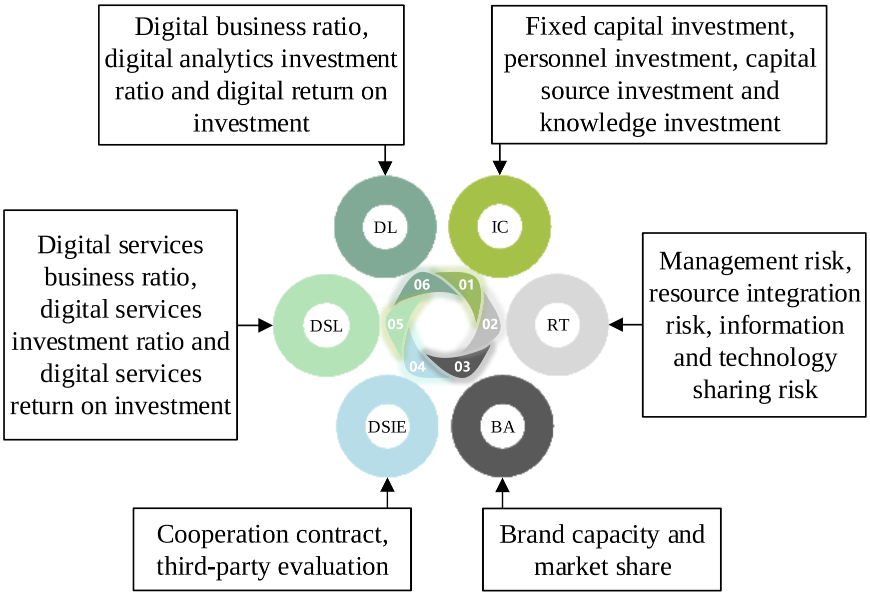

Figure. 2 Composition of correction factor indicators.

4.3. Calculation of correction factors proportion

Step 1: Standardize the original data.

Step 2: Use the entropy method to evaluate. It is an objective weighting method, which uses the size of the information entropy contained in the index to determine the index weight. The smaller the information entropy of the modified index, the more significant the index value change. The more information provided, the greater the weight of the index.

The investment contribution factor $I(I_1, I_2, \cdots, I_n), \sum_{i=1}^{n} I_i = 1$, the benefit distribution result obtained by enterprises participating in the coalitional game is $\eta_1 \times (I_i - \frac{1}{n}) \times v(s)$, $v(s)$ is the total benefits received by enterprises after the cooperation of DSE, and $(I_i - \frac{1}{n})$ is the difference between the corrected comprehensive coefficient and the theoretical distribution coefficient.

The risk-taking factor $R(r_1, r_2, \cdots, r_n), \sum_{i=1}^{n} r_i = 1$, then the benefit distribution result obtained by enterprises participating in the coalitional game is $\eta_2 \times (r_i - \frac{1}{n}) \times v(s)$, $(r_i - \frac{1}{n})$ is the difference between the corrected comprehensive coefficient and the theoretical distribution coefficient.

The digital servitization level factor $S(s_1, s_2, \cdots, s_n), \sum_{i=1}^{n} s_i = 1$, then the benefit distribution results of enterprise i participating in the coalitional game for their different digital servitization level is $\eta_3 \times (s_i - \frac{1}{n}) \times v(s)$.

The digital servitization effort factor $E(e_1, e_2, \cdots, e_n), \sum_{i=1}^{n} e_i = 1$, the benefit distribution result of enterprise i participating in the coalitional game due to their different digital servitization enthusiasm varies is $\eta_4 \times (e_i - \frac{1}{n}) \times v(s)$.

The brand awareness factor $B(b_1, b_2, \cdots, b_n), \sum_{i=1}^{n} b_i = 1$, the benefit distribution result of enterprise i participating in the coalitional game due to the different brand awareness of the product is $\eta_5 \times (b_i - \frac{1}{n}) \times v(s)$.

Step 3: Determine the weight of the correction factor.

The weights of the correction factors will be modified by using expert scoring of the normalization treatment correction factors. The importance of the correction factor is $\eta^* = (\eta_1, \eta_2, \cdots, \eta_6), \eta_i = \frac{A_i}{\sum_{i=1}^{n} A_i}, \sum_{i=1}^{n} \eta_i = 1$.where $A_i = \frac{1 - H_i}{k - \sum H_i}$ represents the entropy weight of each factor, $H_i = -\frac{1}{ln\ m}\sum_{k=1}^{m}(f_{ik} ln f_{ik})$ represents entropy value, $f_{ik} = \frac{X_{ik}}{\sum_{k=1}^{m} X_{ik}}$ indicates the weight of the factor value of the item i under the factor k, X_{ik} indicates the scoring result of the factor i by experts k, m indicates the number of experts invited. Substitute the modified factor into the traditional Shapley value distribution model to obtain the modified Shapley value distribution model. The benefits that enterprise i can share from the total benefits in the DSE s is expressed as:

$$\begin{aligned}\varphi_i^{**} = \varphi_i^{*} + v(s)[\eta_1 \times (i_i - \frac{1}{n}) + \eta_2 \times (r_i - \frac{1}{n}) + \eta_3 \times (s_i - \frac{1}{n}) \\ + \eta_4 \times (e_i - \frac{1}{n}) + \eta_5 \times (b_i - \frac{1}{n})] + \eta_6 \times (d_i - \frac{1}{n})]\end{aligned} \quad (10)$$

4.4. Benefits distribution mechanism

In this section, we discuss how the benefits of a DSE can be distributed so that enterprises in the ecosystem can actively participate in cooperation through the following definitions. We first identified the primary conditions for digital servitization cooperation of enterprises to gain more benefits; Then, we discuss how to allocate benefits in DSE to make sure that each enterprise think it is profitable to remain in DSE without quitting. We will use the 'superadditivity', 'Shapley value' and 'Core of coalitional game' in coalitional game theory to solve the problem of benefits distribution in DSE. Ecosystem members can involve in other DSE, thus generating different interests.

Definition 1. Superadditivity

Let v be the characteristic function of participant set N. For DSE s and t,if $v(s \bigcup t) \geq v(s) + v(t)$, for any s,there is $s \bigcap t = \varnothing$. And the characteristic function of participant set N satisfies the superadditivity of v. Definition 1 meets the requirements of assumption 2. So, we can get theorem 1 based on definition 1.

Theorem 1. Assume that any DSE s， $t \subseteq N$ meets $s \bigcap t = \varnothing$, only if the enterprises cooperate, coalitional game of DSE N, v meets the super-additivity.

Theorem 1 provides the conditions that menbers are willing to cooperate in DSE. Then, coalitional game of DSE N, v meets the requirement of superadditivity.

Definition 2. Shaley values

For the coalitional game N, there are three principles of reasonable distribution. In the n-person coalitional game $[I, V]$, the basic nature that the participants i should meet in the benefits $\varphi_i(V)$ from the coalitional game, and then prove that the coalitional game solution that meets these basic properties is the only one, and then properly solve the reasonable distribution problem of a certain type of coalitional game.

(1) The principle of symmetry: the benefits distribution obtained by each participant due to cooperation has nothing to do with his position in the set $I = [1, 2, ..., n]$;

(2) The principle of effectiveness: if the game subject has no contribution to the cooperation of DSE he participates in, the distribution to him should be 0, and the Shapley value is the total amount of benefits distribution;

(3) The principle of additivity: if n individuals participate in multiple non-influenced cooperation at the same time, the distribution of numerous cooperation should also be non-influenced, that is, the distribution amount of people in the bureau is the sum of the distribution amount of individual cooperation when participating in multiple cooperation.

The three principles given in Definition 2 have the following results. First, the principle of symmetry indicates that if a DSE s is in DSE N, participant i and participant j is not in DSE s. If the DSE s and participant i can obtain the same interests as the DSE s and participant j, the interests of the participant i in the DSE N are equivalent to the interests of the participant j in the DSE N. Secondly, principle of effectiveness refers to the sum of total benefits of all participating members in the DSE are equal to the comprehensive benefits of the DSE N as a whole. Third, the principle of additivity represents the total revenue of all participating individuals in the DSE U and the DSE M, is equivalent to the total benefit of all the individual participants in the DSE U and the DSE M.

Definition 3. Core of coalitional game

Although there are unlimited allocations in the feasible allocation set $E(v)$, there are many allocations that will not be executed or accepted by participants. In a n-person coalitional game (N,v), the set formed by all the optimal allocation schemes is called the core of the coalitional game, which is recorded as $C(v)$, apparently $C(v) \subseteq E(v)$. If the vector φ in is used as a distribution $C(v) \neq \varnothing$, φ will satisfy both individual rationality and collective rationality, then the set of all optimal distributions is the core of DSE. Referring to Definition 3, we can get the following theorem.

Theorem 2. The benefit distribution mechanism $\varphi(v) = \{\varphi_1(v), \varphi_2(v), ..., \varphi_n(v)\}$ is the core of the coalitional game of DSE.

Theorem 2 shows that the benefits distribution mechanism of enterprises in DSE can ensure the steadiness of coopetition only when the mechanism meets the core of the coalitional game. Then, the Shapley value of member i can be expressed by the following formula (11):

$$\varphi_i(v) = \sum_{S \subseteq N \setminus i} \frac{|S|!(n-|S|-1)!}{n!}(v(S \cup \{i\}) - v(S)) \qquad (11)$$

5. Numerical analysis

Through parameter adjustment and simulation process observation, this section discusses the six factors of IC, DSL, DL, RT, DSE and BA on the benefit of enterprise DSE, and discusses the influence of enterprise benefit distribution mechanism.

5.1. Case study

In this case study, enterprises $i = 1, 2, 3$ build a DSE and transform it based on product technology, digital technology and customer data sharing. The ecosystem includes manufacturers, service providers and data providers. In this case, a coalitional game model $(\{1, 2, 3\}, v)$ can be established. The benefit of the enterprise includes the product and service. The sales and operation of the service will have an impact on the sales of the product and change the proportion of the profit source of the enterprise.

For ease of calculation, we only consider the digital servitization component of the benefit distribution for the DSE enterprises. Then, according to the case study, when the data provider A, service provider B and manufacturer C independently carry out digital servitization, the benefit they can obtain in the digital service part is 100 ten thousand yuan, 200 ten thousand yuan and 150 ten thousand yuan respectively. A can get total benefit of 400 ten thousand yuan when cooperating with B, and 300 ten thousand yuan when cooperating with C; B can get total income of 400 ten thousand yuan when cooperating with C. The tripartite cooperation can obtain a total benefit of 600 ten thousand yuan.

5.1.1 Traditional Shapley value distribution

According to the above data, the benefits distribution results of each manufacturing enterprise can be obtained by substituting into formula (1) and formula (2). k=A, B, C represents the constituent members of DSE, s-k indicates the member k removed by the s. Then, the benefits distribution of enterprises A, B, C can be shown in Table 3.

Table 3. Benefits distribution results of enterprises A, B, C.

S	v(s)	v(s-k)	v(s)-v(s-k)	w(|s|)	w(|s|) [v(s)-v(s-k)]
A	100	0	100	1/3	100/3
A-B Cooperation	400	200	200	1/6	200/6
A-C Cooperation	300	150	150	1/6	150/6
B	200	0	200	1/3	200/3
B-A Cooperation	400	100	300	1/6	300/6
B-C Cooperation	400	150	250	1/6	250/6
C	150	0	150	1/3	150/3
C-A Cooperation	300	100	200	1/6	200/6
C-B Cooperation	400	200	200	1/6	200/6
Tripartite Cooperation	600	400	200	1/3	200/3

According to Table 3, the benefit of the data provider A is 100/3+200/6+150/6+200/3=475/3 ten thousand yuan. Similarly, the service provider B's benefit is 773/3 ten thousand yuan, and the manufacturer C's benefit is 550/3 ten thousand yuan. At this time, the impact of enterprise cooperation of IC, DSL, DL, RT, DSE and BA on benefit is not considered, and the income gap between the three parties is large, which is not conducive to the stability of DSE.

5.1.2 Modified Shapley value distribution

Before the Shapley value benefit distribution, it is necessary to determine the proportion of the six factors of the enterprise's factors of IC, DSL, DL, RT, DSE and BA. Obtain the ratio of each factor according to 4.2. Correction index identification, IC, DSL, DL, RT, DSE, and BA of the three enterprises are shown in Table 4.

Table 4. Original data table.

Alliance members	Investment contribution	Risk-taking	Digital servitization level	Digital servitization effort	Brand awareness	Digitalization level
A	0.42	0.19	0.07	0.23	0.09	0.05
B	0.39	0.22	0.73	0.65	0.65	0.35
C	0.19	0.47	0.10	0.12	0.26	0.60

Experts in the fields of servitization and digitalization are invited to score the impact of six factors, IC, DSL, DL, RT, DSE and BA, on digital servitization when manufacturers, service providers and data providers cooperate, and Table 5 is obtained.

Table 5. Expert scoring table.

Correction factors / Experts	IC	RT	DSL	DL	DSIE	BA
Expert I	4	4	5	5	4	3
Expert II	3	4	5	3	2	2
Expert III	5	3	5	4	2	3
Expert IV	4	4	4	4	2	3
Expert V	5	4	5	4	3	3
Expert VI	3	5	4	3	2	3
Expert VII	4	5	4	2	3	3
Expert VIII	4	4	5	4	3	4
Total	32	33	37	29	21	24

In the table, 5-4 points (including 4 points) indicate strong effects, 4-3 points (including 3 points) indicate distinct effects, 3-2 points (including 2 points) indicate moderate effects, and 2-1 points (including 1 point) indicate poor effects.

The scores of the six indicators of IC, DSL, DL, RT, DSE and BA were normalized (that is, heterogeneous indicators were homogenized). IC, RT and DSE are processed as negative indicators, while DSL, BA and DL are processed as positive indicators, the weight matrix of the six correction factors IC, DSL, DL, RT, DSE and BA is obtained according to the entropy-expert score: $\eta^* = (0.277, 0.100, 0.246, 0.102, 0.101, 0.174)$.

It can be seen that the factors affecting the benefit distribution of DSE in order of importance from large to small are: IC, DSL, BA, DL, DSE, RT. Then, after modification, the final benefit distribution of the available enterprise is shown in the following table.

Table 6. Comparison of enterprises' benefit distribution under different forms of cooperation.

Alliance menbers	Benefits of non-cooperation	Traditional Shapley value benefit distribution	Modified Shapley value benefit distribution	Benefit growth before modified	Benefit growth after modified
A	100	152.33	138.95	0.5233	0.3895
B	200	257.67	279.24	0.2884	0.3962
C	150	183.33	172.68	0.2222	0.1512

Comparing the results of benefit distribution between competition and cooperation, we can know that, first of all, the modified Shapley value model is an effective tool to solve the problem of multi-member benefit distribution. From the perspective of benefit growth, the standard Shapley value model only considers the impact of the investment contribution ability of members in DSE, and the data provider A obtains the highest benefit growth. The revised Shapley value model considers the factors that affect the benefit distribution among the members of DSE, such as IC, DSL, DL, RT, DSE, BA, etc., and thinks that the comprehensive contribution ability of service provider B is better.

According to the raw data table, it can be seen that the risk-taking ratio of service provider B is 0.73, which is much higher than data provider A and manufacturer C. The result of distribution conforms to the principle of 'high risk - high return', and verifies the correctness of expert estimation and judgment. Secondly, the reduction of the benefits of data provider A and service provider B encourages members to pay attention to their competitive advantages, but also to cooperate and learn from each other, so as to enhance the overall benefits of DSE.

The DSE will be an inevitable choice for enterprises to explore new markets for specialized division of labor and cooperation in the long run of digital servitization transformation. Because the total benefits of the DSE will show a gradual growth trend. Therefore, the modified Shapley value model provides a scientific and reasonable distribution strategy for the benefit distribution of DSE, and has a good application prospect.

5.2. Analysis of sensitivity

Based on the basic assumptions of our model, we conduct a sensitivity analysis of the correction factors that affect the benefit distribution of DSE enterprises. Combined with the above case analysis, let $\varphi_A^* = 152.33,\ v(s) = 100,\ n = 3,\ i_A = 0.42,\ r_A = 0.22,\ s_A = 0.07,$ $e_A = 0.23,\ b_A = 0.09,\ d_A = 0.05$, to obtained the simulation results of Figure 3.; Let $\varphi_B^* = 257.67,\ v(s) = 200,\ n = 3,\ i_B = 0.39,\ r_B = 0.47,\ s_B = 0.73,\ e_B = 0.65,\ b_B = 0.65,\ d_B = 0.35$ we obtained the simulation results of Figure 4.; Let $\varphi_C^* = 183.33$, $v(s) = 150$, $n = 3$, $i_C = 0.19$, $r_C = 0.31$, $s_C = 0.10$, $e_C = 0.12$, $b_C = 0.26$, $d_C = 0.60$, we obtained the simulation results of Figure 5.

It can be seen from Figure. 3, Figure. 4, and Figure. 5 that the resource input and risk-taking capacity of enterprises for digital servitization transformation have similar effects on their benefit distribution, while the impact of digital servitization level and digitalization level on the income distribution of enterprises in the ecosystem is specific to certain types of enterprises.

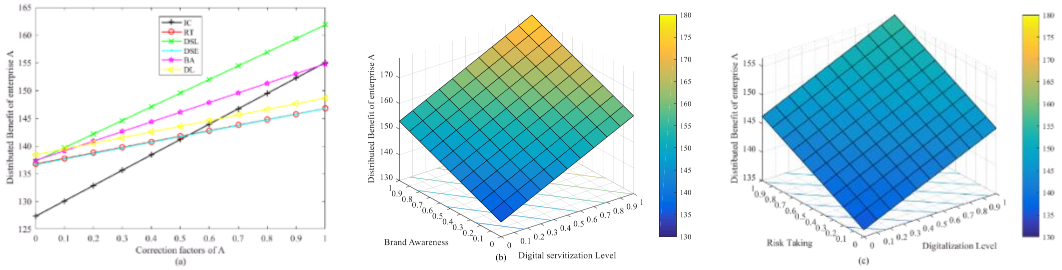

Figure 3. Results of data provider A's benefit distribution, (a) Benefit distribution affected by correction factors, (b) Benefit distribution synergistically affected by digital servitization level and brand awareness, (c) Benefit distribution synergistically affected by digitalization level and risk-taking.

Figure 3. (a) shows the impact of correction factors on the benefit distribution of data provider A in the DSE. It can be seen that the benefit of data provider A is greatly affected by IC, DSL, and BA. This is because the data provider A is closer to the customer and has strong data identification and transformation technology, which is in line with the characteristics of customer orientation, data-driven and digitalization of digital services (Pathak, Ashok, and Tan 2020; Gaiardelli et al. 2021), the main services of the business cover design, operation and maintenance.

According to Figure 3. (b), it is found that under the synergistic influence of brand capability and digital servitization level of data provider A, the digital servitization level dominates the benefit distribution, because data provider A have gained sufficient visibility when they carry out digital transformation through digital technology, and customers are more concerned about the service provided through digital technology.

At the same time, Figure 3. (c) shows little change in data provider A returns under the synergistic influence of digitization level and risk-taking capacity, as digitization is more resilient to risk. For example, Red Hat is committed to providing open-source solutions with security enhancements, from the core data center to the network edge, focusing on making it easier for enterprises to work across platforms and environments.

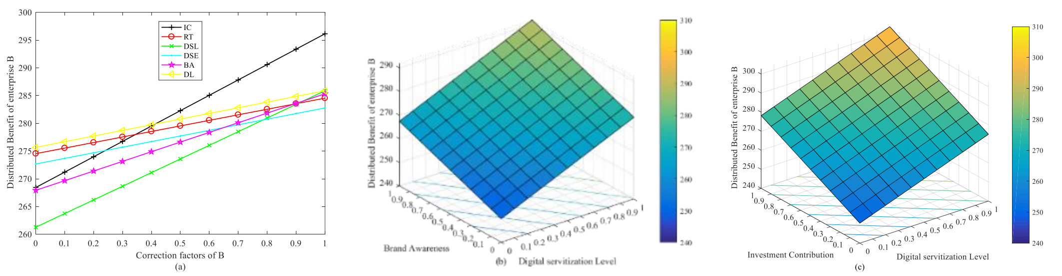

Figure 4. Results of service provider B's benefit distribution, (a) Benefit distribution affected by correction factors, (b) Benefit distribution synergistically affected by digital servitization level and brand awareness, (c) Benefit distribution synergistically affected by digital servitization level and investment contribution.

Figure 4. (a) shows how the benefit distribution of service provider B in DSE is affected by correction factors. Compared with other factors, digital servitization investment resources and risk-taking capacity have a greater impact on service provider B. This is because in the enterprise DSE, service provider B have the highest coefficient of digital servitization level, service providers mainly take service as the core business, and the digital services provided by enterprises have higher innovation value, realizing service-driven business development. Therefore, service providers meet the innovation-driven characteristics of digital servitization (Dalenogare et al. 2022; Kolagar, Parida, and Sjödin 2022).

According to Figure. 4 (b) and Figure. 4 (c), it is found that under the synergistic influence of digital servitization level and brand capability, as well as digital servitization level and investment contribution capability, service provider B have a flat impact on benefit distribution, because the benefit of service provider B is mainly in the service business, and service imitation among peers requires strong brand capability to resist. At the same time, sufficient investment in digital servitization can make the digital servitization innovation more in-depth and restrain the imitation of peers in the short term. IBM, for example, uses AI, automation, hybrid cloud, and other digital technologies to drive intelligent workflows with data, make faster and smarter decisions, and respond to market disruptions in real-time.

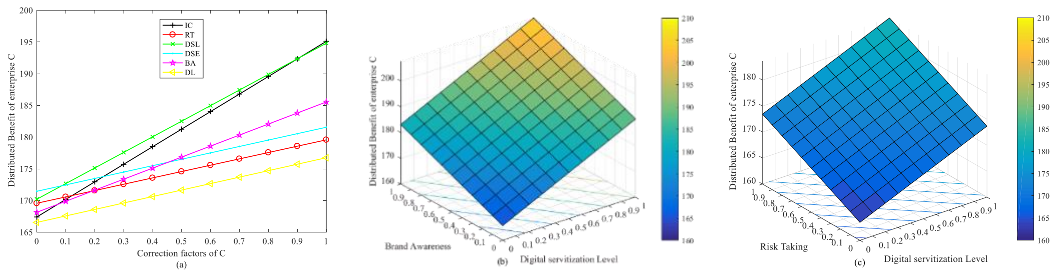

Figure 5. Results of manufacturer C's benefit distribution, (a) Benefit distribution affected by correction factors, (b) Benefit distribution synergistically affected by digital servitization level and brand awareness, (c) Benefit distribution synergistically affected by digital servitization level and risk-taking.

Figure 5. (a) shows the effect of correction factors on manufacturer C's benefit distribution in the DSE. It can be seen that the benefit of manufacturer C is greatly affected by IC, DSL and BA. This is because manufacturer C also provide products in the process of digital servitization, which can provide customers with personalized digital services based on products. At this point, the brand has a greater impact on the sales of products and digital services. Therefore, manufacturer C meet the characteristics of personalization and cross-border integration of digital services (Dou et al. 2021; Kolagar, Parida, and Sjödin 2022).

According to Figure 5. (b), the increase in the impact of the digital servitization level on benefit distribution exceeds the impact of digital service innovation input and risk-taking capacity. This is because manufacturer C are significantly affected by digital servitization level and investment contribution ability, and it is difficult to transfer the brand ability of products to the developed services, and service is easy to be imitated. At this time, the services are mainly supplements and extensions of products, such as Siemens building technology services, ProductCRET services, etc.

According to Figure 5. (c), the benefit distribution of manufacturers is flattened by the synergistic influence of digitization level and risk-taking capacity, and the influence of digital servitization level is significant. Under the synergistic influence of digital servitization level and brand capability, the benefit distribution of manufacturer C changes more significantly, which indicates that traditional manufacturing enterprises need to improve their digital servitization level and product brand capability at the same time in order to gain better advantages in the ecosystem. For example, Siemens focuses on the industrial, infrastructure, transportation and medical fields, especially in additive manufacturing, which is known as the next revolution in industrial manufacturing. Siemens is currently one of the few companies that cover all aspects of the additive manufacturing value chain with integrated software and hardware.

These enterprises with complementary capabilities set up a DSE, which will benefit their digital servitization development. For example, the strategic alliance of Siemens, IBM and Red Hat leverages a specially designed hybrid cloud to innovate service solutions that help customers derive real-time value from operational data. Open data access based on Red Hat's Kubernetes platform and IBM's open hybrid cloud solution integrated into Siemens' service solution MindSphere. Organizations use MindSphere to collect and analyze data from products, plants, systems, and machines, enabling users to optimize products, production assets, and manufacturing processes across the value chain to build real-time digital twins that further highlight the role of service elements in digital environment innovation.

6. Conclusion

6.1. Theoretical implications

This paper discusses the benefit-maximization decisions of manufacturer, service provider and data provider, which are affected by relevant correction factors when they build a DSE. By introducing correction factors to the benefit distribution of the enterprise DSE, we construct the traditional Shapley value benefit distribution model and the modified Shapley value benefit distribution model of DSE to compare and analyze the difference. Based on the traditional Shapley value model, we comprehensively consider the differences among ecosystem members in six factors: investment contribution capacity, risk-taking capacity, digital servitization level, effort level, brand capability and digitalization level, and establish a modified Shapley value benefit distribution model. It makes up for the defect of the traditional Shapley value model which only considers the average contribution of members. It is of great significance to explore the benefit distribution of the ecosystem enterprises under the modified factor, so as to realize the fair and lasting operation of DSE. Specifically, the results and implications are as follows:

First of all, in the benefit distribution of DSE, attention should be paid to the contribution level of each member, the digital servitization level, brand capability and digitalization level, which will directly relate to the value co-creation of DSE. Our research confirms that the influencing factors of enterprise innovation come from internal and external researches (Wang, Wang, and Mardani 2023; Arora, Belenzon, and Patacconi 2021). However, we show that external digital servitizatioin investment contribution ability, brand ability, internal digital servitization level and digitalization level are key factors that affect the benefit distribution of DSE, which has an important impact on enterprises' evaluation of the pros and cons of DSE construction.

Secondly, the modified Shapley value benefit distribution mechanism can maintain the stability of DSE. Through the introduction of correction factors, we can correct the benefit distribution mechanism of Shapley value method, optimize the benefit distribution within the ecosystem, and enhance the members' willingness to adhere to the ecosystem. The research shows that the correction of Shapley value benefit distribution mechanism can avoid the 'free rider' effect in DSE, enable members to achieve a multi-win situation, ease the tension in the ecosystem, and promote the digital servitization transformation of members.

Finally, digital servitization is a collaborative process, and the leading role of digital servitization and supporting role of digitalization will significantly affect the stable development of the ecosystem. Research on benefit distribution of innovation alliance (Jiang et al. 2021; Wang, Wang, and Mardani 2023) usually focuses on resource investment and risk taking. On this basis, we pay attention to the impact of different capabilities of digital servitization on benefit from the perspective of value co-creation, and show that digital servitization level has a significant impact on enterprises' digital servitization cooperation and the promotion role of digitalization level. At the same time, the influence of brand capability on service imitation is considered in the competition and cooperation of digital service, and the sharing of technology and data in cooperation is highlighted, which has an important impact on the transformation strategy and development mode selection of enterprises in DSE.

6.2. Management insights

The establishment of DSE plays an important role in the transformation of enterprise digital servitization. We have obtained several research results by developing a benefit distribution model for enterprise DSE. We provide some management insights for enterprise digital servitization transformation, which can provide new ideas for avoiding 'free rider' effect in enterprise digital servitization transformation cooperation, which is explained by the following aspects.

(1) The establishment of a digital servitization ecosystem by enterprises can achieve value co-creation and avoid the 'free-rider' effect through the benefit distribution mechanism. By sharing product technology (such as KONE's elevator technology) with manufacturer, providing digital technology (such as failure prediction) with service providers, and sharing customer data with data providers, it makes it easier for ecosystems to transform into digital servitization. By designing a benefit distribution mechanism according to the different capabilities of each member in the

ecosystem (such as digital service capabilities), enterprises can achieve fair distribution and avoid the 'free rider' effect.

(2) Digital servitization cooperation can reduce the risk of digital servitization transformation failure of ecosystem members, and the correction of Shapley benefit distribution can promote the stability of digital servitization ecosystem. Specifically, when the ecosystem enterprise collaborates as a digital service, knowledge, technology, and data are shared among members (i.e., complementary capabilities) to better share transformation risks. Managers need to realize that a balanced distribution of benefits incentivizes participation and contribution, and maintains ecosystem stability.

(3) The digital servitization ecosystem requires cooperation and synergy among all participants in order to achieve greater benefits. Enterprises with a high digital servitization level (such as a high proportion of digital service business) can establish a digital servitization ecosystem and share technology and customer data with enterprises with a low level of digital service, which can complement each other's capabilities, and then transfer some of the risks of digital servitization. Managers, then, should promote collaboration among participants, for example by building deeper partnerships and working with companies that complement each other's capabilities, to improve the stability and effectiveness of the entire ecosystem.

6.3. Limitations and future work

There are still several limitations to our study that could be further studied in the future. First, we mainly consider the benefut distribution of DSE based on product technology, digital technology and customer data-sharing cooperation. Further research can discuss the distribution of benefits for corporate partnerships with different types of input resources and different technologies (e.g., big data marketing inputs, digital technologies, etc.). Secondly, we assume that the game of enterprises in DSE is cooperative and continuous. Further research could extend our model by considering the effects of ecosystem duration and information asymmetry. Finally, our model applies only to DSEs that consider only horizontal competition and cooperation. Therefore, focusing on both vertical competition and cooperation in a DSE can further expand our research. For example, customer participation is introduced into the process of digital servitization, and the degree of cooperation and the way of value co-creation is analyzed in each stage of enterprise digital servitization transformation.

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References

Alnawas, I., and Hemsley-Brown, J. 2019. "Market orientation and hotel performance: investigating the role of high-order marketing capabilities." *International Journal of Contemporary Hospitality Management* 31(4): 1885-1905. https://doi.org/10.1108/IJCHM-07-2018-0564.

Arora, A., Belenzon, S., and Patacconi, A. 2021. "Knowledge sharing in alliances and alliance portfolios." *Management Science* 67(3): 1569-1585. https://doi.org/10.1287/mnsc.2020.3614.

Arslan, B. 2018. "The interplay of competitive and cooperative behavior and differential benefits in alliances." *Strategic Management Journal* 39(12): 3222-3246. https://doi.org/10.1002/smj.2731.

Dalenogare, L. S., Le Dain, M. A., Ayala, N. F., Pezzotta, G., and Frank, A. G. 2023. "Building digital servitization ecosystems: An analysis of inter-firm collaboration types and social exchange mechanisms among actors." *Technovation* 124: 102756. https://doi.org/10.1016/j.technovation.2023.102756.

Dalenogare, L. S., Le Dain, M. A., Benitez, G. B., Ayala, N. F., and Frank, A. G. 2022. "Multichannel digital service delivery and service ecosystems: The role of data integration within Smart Product-Service Systems." *Technological Forecasting and Social Change* 183: 121894. https://doi.org/10.1016/j.techfore.2022.121894.

Dou, R., Li, W., Nan, G., Wang, X., and Zhou, Y. 2021. "How can manufacturers make decisions on product appearance design? A research on optimal design based on customers' emotional satisfaction." *Journal of Management Science and Engineering* 6(2): 177-196. https://doi.org/10.1016/j.jmse.2021.02.010.

Gaiardelli, P., Pezzotta, G., Rondini, A., Romero, D., Jarrahi, F., Bertoni, M., ... and Cavalieri, S. 2021. "Product-service systems evolution in the era of Industry 4.0." *Service Business* 15: 177-207. https://doi.org/10.1007/s11628-021-00438-9.

Gebauer, H., Paiola, M., Saccani, N., and Rapaccini, M. 2021. "Digital servitization: Crossing the perspectives of digitization and servitization." *Industrial Marketing Management* 93: 382-388. https://doi.org/10.1016/j.indmarman.2020.05.011.

Hänninen, M., Mitronen, L., and Kwan, S. K. 2019. "Multi-sided marketplaces and the transformation of retail: A service systems perspective." *Journal of Retailing and Consumer Services* 49: 380-388. https://doi.org/10.1016/j.jretconser.2019.04.015.

Huang, X. X., Guo, P., Wang, X. N., and Wang, D. 2021. "Analysis on the Cooperative Innovation Behavior and Stability of Inter-organizational R&D Project Based on Evolutionary Game." *In 2021 IEEE International Conference on Industrial*

Engineering and Engineering Management (IEEM) 942-946. https://doi.org/10.1109/IEEM50564.2021.9672915.

Jacobides, M. G., Cennamo, C., and Gawer, A. 2018. "Towards a theory of ecosystems. " *Strategic Management Journal* 39(8): 2255-2276. https://doi.org/10.1002/smj.2904.

Jiang, X., Wang, L., Cao, B., and Fan, X. 2021. "Benefit distribution and stability analysis of enterprises' technological innovation cooperation alliance." *Computers & Industrial Engineering* 161: 107637. https://doi.org/10.1016/j.cie.2021.107637.

Kokkonen, K., Hannola, L., Rantala, T., Ukko, J., Saunila, M., and Rantala, T. 2023. "Preconditions and benefits of digital twin-based business ecosystems in manufacturing." *International Journal of Computer Integrated Manufacturing* 36(5): 789-806. https://doi.org/10.1080/0951192X.2022.2145022.

Kolagar, M., Parida, V., and Sjödin, D. 2022. "Ecosystem transformation for digital servitization: A systematic review, integrative framework, and future research agenda." *Journal of Business Research* 146: 176-200. https://doi.org/10.1016/j.jbusres.2022.03.067.

Leng, M., Luo, C., and Liang, L. 2021. "Multiplayer allocations in the presence of diminishing marginal contributions: Cooperative game analysis and applications in management science." *Management Science* 67(5): 2891-2903. https://doi.org/10.1287/mnsc.2020.3709.

Liu, C., Ji, H., and Ji, J. 2022. "Mobile information technology's impacts on service innovation performance of manufacturing enterprises." *Technological Forecasting and Social Change* 184: 121996. https://doi.org/10.1016/j.techfore.2022.121996.

Liu, W., Wei, S., Li, K. W., and Long, S. 2022. "Supplier participation in digital transformation of a two-echelon supply chain: Monetary and symbolic incentives." *Transportation Research Part E: Logistics and Transportation Review* 161: 102688. https://doi.org/10.1016/j.tre.2022.102688.

Liu, W., Wei, S., Shen, X., and Liang, Y. 2023. "Coordination mechanism of logistic service supply chain: a perspective of presale sinking and risk aversion." *European Journal of Industrial Engineering* 17(2): 310-341. https://doi.org/10.1504/EJIE.2023.129459.

Liu, S., and Papageorgiou, L. G. 2018. "Fair profit distribution in multi-echelon supply chains via transfer prices." *Omega* 80: 77-94. https://doi.org/10.1016/j.omega.2017.08.010.

Manresa, A., Prester, J., and Bikfalvi, A. 2021. "The role of servitization in the capabilities–performance path." *Competitiveness Review: An International Business Journal* 31(3): 645-667. https://doi.org/10.1108/CR-01-2020-0017.

Manser Payne, E. H., Dahl, A. J., and Peltier, J. 2021. "Digital servitization value co-creation framework for AI services: a research agenda for digital transformation in financial service ecosystems." *Journal of Research in Interactive Marketing* 15(2): 200-222. https://doi.org/10.1108/JRIM-12-2020-0252.

Marcon, É., Marcon, A., Ayala, N. F., Frank, A. G., Story, V., Burton, J., ... and Zolkiewski, J. 2022. "Capabilities supporting digital servitization: A multi-actor

perspective." *Industrial Marketing Management* 103: 97-116. https://doi.org/10.1016/j.indmarman.2022.03.003.
Paschou, T., Rapaccini, M., Adrodegari, F., and Saccani, N. 2020. "Digital servitization in manufacturing: A systematic literature review and research agenda." *Industrial Marketing Management* 89: 278-292. https://doi.org/10.1016/j.indmarman.2020.02.012.
Pathak, B., Ashok, M., and Tan, Y. L. 2020. "Value co-destruction: Exploring the role of actors' opportunism in the B2B context." *International Journal of Information Management* 52: 102093. https://doi.org/10.1016/j.ijinfomgt.2020.102093.
Peng, Y., Chen, B., and Lee, C. C. 2023. "Equilibrium in platform service supply chain network with quality and innovation considering digital economy." *Annals of Operations Research* 1-30. https://doi.org/10.1007/s10479-023-05351-0.
Peng Y, Chen, L, Dou, R, Hou, Y. 2023. "Service innovation decision for manufacturing enterprises based on a coopetition perspective." *Computers & Industrial Engineering* 183: 109496. https://doi.org/10.1016/j.cie.2023.109496.
Struckell, E., Ojha, D., Patel, P. C., and Dhir, A. 2021. "Ecological determinants of smart home ecosystems: A coopetition framework." *Technological Forecasting and Social Change* 173: 121147. https://doi.org/10.1016/j.techfore.2021.121147.
Vandermerwe, S. and Rada, J. 1988. "Servitization of Business: Adding Value by Adding Services." *European Management Journal* 6(4): 314-324. https://doi.org/10.1016/0263-2373(88)90033-3.
Wang, M., Wang, Y., and Mardani, A. 2023. "Empirical analysis of the influencing factors of knowledge sharing in industrial technology innovation strategic alliances." *Journal of Business Research* 157: 113635. https://doi.org/10.1016/j.jbusres.2022.113635.
Wang, Y., Zhao, Z., and Baležentis, T. 2023. "Benefit distribution in shared private charging pile projects based on modified Shapley value." *Energy* 125720. https://doi.org/10.1016/j.energy.2022.125720.
Zeynivand, M., Ranjbar, H., Radmanesh, S. A., and Fatahi Valilai, O. 2021. "Alternative process routing and consolidated production-distribution planning with a destination oriented strategy in cloud manufacturing." I*nternational Journal of Computer Integrated Manufacturing* 34(11): 1162-1176. https://doi.org/10.1080/0951192X.2021.1972459.