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A Sustainable Innovation Strategy Oriented toward Complex Product Servitization

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Abstract: Enterprises performing complex product servitization are more vulnerable to the 2019 coronavirus disease (COVID-19) pandemic because of their large number of suppliers and wide coverage, among other things. The present research focuses on how to promote the sustainable innovation of complex product servitization. We investigate complex products and sustainable innovation—factors influencing the sustainable innovation of complex product servitization—based on the characteristics of product servitization and by combining the definitions of product servitization. We find that inadequate innovation ability and poor technical research and development (R&D) competence are the primary concerns in the sustainable innovation of complex product servitization. Specific to innovation ability improvement, the sustainable innovation of complex product servitization must follow an innovation-driven development strategy, a hard power cultivation strategy, and a soft power cultivation strategy. In terms of technical R&D competence enhancement, technological innovation strategies, integrated outsourcing of technical R&D competence, and independent improvement of technical R&D competence must be implemented to facilitate the sustainable innovation of complex product servitization.

Keywords: complex product servitization; sustainable innovation; technological innovation

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1. Introduction

The term "complex product" refers to high-value products manufactured using advanced technology and complex processes. A complex product comprises many parts and components and has a diversified and varied relationship with these accessories. Typical complex product manufacturing sectors include aerospace, the large electronics information industry, and the large equipment manufacturing industry. In recent years, complex product manufacturing has shown a development tendency toward servitization. Product servitization means that the manufacturing industry is transitioning from simply providing products to product-service packages, that is, to provide more comprehensive product services, support services, and knowledge services to customers. Thus, their service characteristics are highlighted, and the value of relevant products can be increased by virtue of such services [1]. China, for example, a big producer in manufacturing, has no global advantage in terms of the competitiveness of its manufacturing industry. Complex product manufacturing is generally at the bottom of the global value chain because of insufficient innovation ability and poor complex modularization technology, which may adversely affect China's international competitiveness. Therefore, complex product manufacturers must boost their competitiveness through product servitization.

In transitioning traditional manufacturing to service-oriented manufacturing, product servitization has become a development tendency in this industry. Under this background, complex product servitization must advance with the times and promote sustainable innovation. Innovation is the core driving force of corporate growth. The complex product manufacturing industry, which features intensive technical knowledge and complicated

manufacturing processes, has a high demand for and sensitivity to innovation. Sustainable innovation based on product servitization is an inevitable requirement of responding to current development trends. Complex product servitization oriented sustainable innovation strategies are seldom investigated in the existing academic research. Relevant studies primarily focus on product servitization and the sustainable innovation ability of enterprises. For example, [2] highlighted that corporate development must attach more importance to product services and provide customers with more comprehensive product services. As suggested by [3], product services may yield stable profits, and sustainable innovation is beneficial for boosting economic growth. Nevertheless, a few monographic studies are available on sustainable innovation oriented to complex product servitization. Consequently, they are less likely to provide effective theoretical guidance for enterprises.

At present, the 2019 coronavirus disease (COVID-19) is having a profound influence on global supply and industry chains. With numerous suppliers and wide coverage, complex products are more easily affected by this epidemic. The manufacturing and assembly of spare parts may be collaboratively completed in different countries. However, under the influence of COVID-19, the interflows of international trade and industrial production are impaired, thereby making independent production of complex products a major appeal, whereas insufficiency in innovation and production capabilities restricts the sustainable development of complex product services. Therefore, investigating sustainable innovation strategies for complex product servitization in the context of COVID-1 is crucial. Sustainable innovation strategies oriented to complex product servitization are selected as this paper's research object to explore the factors influencing complex product servitization-oriented sustainable innovation based on relevant existing research in the post-pandemic era. Finally, sustainable innovation strategies oriented to complex product servitization are raised, thereby providing theoretical references for its sustainable innovation and boosting both the transition to complex product servitization and the improvement of market competitiveness.

The present paper is organized as follows. Section 2 presents a literature review; the primary characteristics of complex product servitization are put forth in Section 3; the factors influencing complex product servitization-oriented sustainable innovation are investigated in Section 4; we probe sustainable innovation strategies oriented toward complex product servitization in Section 5; and the primary conclusions are drawn, and research prospects described, in Section 6.

2. Literature Review

The present study is targeted at sustainable innovation strategies oriented toward complex product servitization. Therefore, this study is concerned with product servitization, complex products, and sustainable innovation. In this section, an overview of these three aspects is provided.

2.1. Product Servitization Research Progress

At present, the research on product servitization is dependent on conceptual definitions and relevant cases and practice. Product servitization is categorized into three stages by [4]. In the first stage, pure products and services are the primary sources of a company's profit; in the second stage, the combination of products and services is realized; and customer demands are satisfied in the third stage, wherein more knowledge, proposals, and remote services required by customers can be offered in addition to services and products. Some scholars have investigated the values and objectives of implementing product servitization; for example, product servitization benefits corporate profits, creates customer values, and provides competitive advantages [5]. Other scholars believe that the fundamental objective of conducting product servitization is to combine product services and novel services, realize service commercialization, and combine commodities and services [6].

Typical application cases of product servitization at home and abroad are analyzed in the literature. Overseas, Rolls-Royce is a typical case. As a well-known aero-engine

manufacturer, it promotes an engine rental mode that takes the place of its selling mode. Within the contract period of leasing, Rolls-Royce is responsible for all added services, such as maintenance and repair, producing rather high economic benefits for the enterprise. In China, a typical case is Huawei. Instead of simply selling telecommunication equipment, the company further provides cloud computing solutions providing outstanding informationalized solutions for the sector. Thus, Huawei plays an active part in building an inter-industry win–win ecological chain [7]. An empirical case study was conducted by [8] to analyze how product servitization affects the relationship between the purchaser and supplier. By analyzing corporate growth, [9] posits that the application of product servitization must rely on the vertical integration of the supply chain and perform cooperative production by combining traditional/innovative technical means with practical methods. Ref. [10] extracted analytical results from 10,078 enterprises incorporated in the OSIRS database to perform a case study wherein the impacts of product servitization on the efficiency of corporate management are analyzed.

2.2. Progress of Complex Products Research

Based on the related theoretical research, investigations on complex products are primarily aimed at the concepts of industrial upgrading values and innovation driving.

Many scholars have defined the complex product concept. Complex products feature a large number of spare parts, multiple product structure layers, and high values, and they are manufactured based on advanced technology and complex processes [11]. The complex product industry is situated in a comparatively open value network, and thus, the upgrading of this industry is an upgrade of all relevant industries [12]. The term complex product refers to a type of product that has the highest requirements for production technology and corporate production organizational abilities. In the opinion of [13], complex products are twice as complex in terms of both technology and organization. As highlighted by [14], the complex product, which features multiple structure layers, is manufactured by virtue of advanced technology, complex processes, and bulky spare parts.

Regarding research on the industrial upgrading values of complex products, many scholars have posited their own research perspectives. According to [15], upgrading industry clusters is key to regional and national competitiveness, which evidences the influence of industrial upgrading on comprehensive national competitiveness. Regarding complex product manufacturing and services, its internal industrial chain has wide coverage and intensively affects peripheral industries. For this reason, the complex product industry selects the organization form of clustering as its most common production operation mode. Complex product manufacturing is mostly fulfilled by a minority of manufacturers. Consequently, a few manufacturers may have a monopoly on the formulation of international regulations regarding complex product manufacturing. However, this problem may be addressed by complex product upgrading [16]. In addition to supporting industry resource integration, complex product industry upgrading can assist manufacturers in constructing a global division pattern, and controlling the direction of resource integration, can alleviate risks and control costs [17]. Because complex products have low market demand but are high value, adjusting productivity and price is crucial to adjusting its global value chain. Moreover, upgrading the complex product industry is beneficial for adjusting the supply–demand relationship on the global market [18].

In the literature on the innovation-driven development of complex products, this industry's technological innovation ability serves as the core driving force underlying sustainable innovation oriented toward complex product servitization. Compared with other industries, the complex product industry is unique. For example, complex product servitization-oriented sustainable innovation imposes high requirements for technology, and it particularly emphasizes technical complexity and process collocation. In summary, such innovation features system integration and modularized production on the one hand; on the other hand, it attaches substantial importance to innovative R&D based on human intelligence and the interoperability of scientific research structures. The complex product

industry garners strong policy support. Together with the concentrated optimization of hardware and software facilities, they jointly serve to upgrade the complex product industry. Therefore, complex product servitization-oriented sustainable innovation must consider the substantive characteristics of the complex product industry and constantly perform effective upgrading to improve the competitiveness of China's complex product industry and promote its status in the international value chain. Some scholars have further stated that technological innovation and improvement in the quality and competitiveness of spare parts are central to the innovative upgrading of complex products [19]. The complex product has certain technical features, including advanced technology, a complicated production process, and a high degree of refinement. Therefore, innovative progress in the complex product industry must pay particular attention to standardization and intelligence. Thus, not only can its production efficiency be enhanced, the realization of product innovation outcomes can also be boosted [20].

2.3. Research Progress of Sustainable Innovation

Many scholars have explored sustainable innovation, which is defined as an innovation model with sustainable innovation objectives in the innovative development process [21]. Sustainable innovation represents innovation that is beneficial for environmental quality improvement [22]. According to [23], sustainable innovation must be defined in conformity with the law of technological innovation development. Since the emergence of product innovation, sustainable innovation has been further modified along with the production process. Based on market demands, incremental innovation may emerge to generate an innovation cluster promoting the transition from a conventional industry to a new industry. Economist Devendra Sahal posed an evolutionary theory of innovation process wherein technology is constantly developed in the process of unceasingly discovering and correcting mistakes. That is, technology is a product of past innovation and a driving factor of future innovation [24]. Sahal's theory was applied by Wang Yu et al. from China in their research on sustainable innovation of the high and new technology industry.

Research priorities for sustainable innovation are gradually embodied in the details and evaluations of sustainable innovation. Ref. [25] indicated that innovative value, dynamic procedure, and innovation habit are the basic components of sustainable innovation capability. Product innovation, raw material innovation, and process innovation are the primary elements of this capability. Technological and institutional innovation are the main aspects of sustainable innovation. Concrete evaluation criteria for sustainable corporate innovation are reflected in multiple aspects, including resource acquisition and allocation, industrial and technological development prediction, and innovative strategic management abilities [26]. Four indexes are used for evaluating corporate innovation capability—innovative product development ability, technological product reformation ability, technological reserve, and integrated organizational management [27]. Sustainable innovation oriented toward product servitization has not yet been reported.

2.4. A Brief Summary of the Literature

In summary, complex product, product servitization, and sustainable innovation are separately discussed in the existing literature. Sustainable innovation oriented to complex product servitization is seldom investigated. Complexity in complex products determines that sustainable innovation is of substantial significance for their development. Based on the preceding research, sustainable innovation strategies oriented to complex product servitization are explored here for enriching theoretical research results and providing theoretical references for complex product servitization-oriented sustainable innovation.

3. Methodology

The COVID-19 pandemic has had a far-reaching impact on the global supply chain and industrial chain. In order to occupy an important position in the global value chain system, the service-oriented sustainable innovation of complex products is necessary. However,

there is relatively little research on the service-oriented sustainable innovation strategy of complex products, and the formulation of such products lack theoretical reference.

3.1. Research Objective

For the formulation of service-oriented sustainable innovation strategy of complex products, it is important to master the service-oriented characteristics and the influencing factors of such products. Taking the service-oriented characteristics of complex products as the starting point, this paper analyzes the factors affecting their sustainable innovation, and formulates a strategy to implement it.

3.2. Research Hypothesis

(1) Unlike other types of products, complex product service is more complex and difficult in function, production chain, life cycle, and innovation energy.
(2) Innovation ability is the factor affecting the sustainable innovation of complex product service.
(3) Technological research capability is the factor affecting the service-oriented sustainable innovation of complex products
(4) The formulation of scientific sustainable innovation strategy of complex product service is conducive to its sustainable innovation.

3.3. Research Method

3.3.1. Delphi Method

Delphi method, also known as the expert survey method, is essentially a feedback anonymous correspondence method. The main survey process is to design an expert opinion consultation questionnaire according to the research questions. After multiple rounds of opinion collection, the contents of the survey are sorted, summarized, and counted until unified opinions are obtained. Compared with other expert interview methods, Delphi method has the characteristics of anonymous evaluation, multiple feedback, and consensus analysis, which makes the survey content more professional and specific. From May 2021 to July 2021, in order to deeply study the influencing factors of the service-oriented sustainable innovation of complex products, the author investigated 100 relevant experts from China's aerospace manufacturing industry, large-scale electronic information manufacturing industry, and large-scale equipment manufacturing industry (please refer to Appendix A for a copy of the questionnaire).

3.3.2. Factor Analysis

Factor analysis is a statistical method used to extract the principal common factors from a group of variables to interpret the research content. As an approach to principal factor extraction, factor analysis can be used to extract factors of greater importance during data simplification to lay a foundation for further study [28].

A P-dimensional random vector is assumed to meet the condition of $X = \mu + A\overrightarrow{f} = \overrightarrow{e}f = \left(f_1, f_2, \cdots, f_q\right)^T$, which is a q-dimensional random variable, and is subjected to $q \leq p$, $E\overrightarrow{f} = 0$, $E\overrightarrow{f}\overrightarrow{f}^T = \overrightarrow{I}_q$, f_i, a common factor influencing each component to be examined. $\overrightarrow{e} = \left(e_1, e_2, \cdots, e_q\right)^T$ is a p-dimensional random vector with nonobservability, $E\overrightarrow{f}\overrightarrow{e}^T = 0$ is established, and component $\overrightarrow{e}_i$ of e is a specific factor that only applies actions on component $\overrightarrow{X}_i$ of X. Furthermore, μ and A represent a parameter matrix. If factor X satisfies the aforementioned equation, the random vector X has a factor structure. Through further calculations, the expression $Var(X) = \overrightarrow{A}\overrightarrow{A}^T + \sum$ is obtained, where matrix A is referred to as the factor loading. Item a_{ij} stands for the load on the jth factor f_j applied by the ith component $\overrightarrow{X}_i$. Therefore, the equation $h_i^2 = \sum_{j=1}^{q} a_{ij}^2$ can be specified to derive another

equation, $Var(X_i) = h_i^2 + \sigma_i^2$. According to the aforementioned expression, h_i^2 is a response of the common factor to the impact of $\vec{X}_i$. Academically, it is called the "contribution" of the common factor to $\vec{X}_i$. Under $f_j \geq \sigma_i^2$, this finding indicates that the influence of a common factor on $\vec{X}_i$ is more significant than that of the specific factor $\vec{e}_i$. Therefore, component $\vec{X}_i$ of h_i^2 is dependent on the interior of the common factor f_j. If common factor f_j is definitely established during research, the equation can be expressed as $g_i^2 = \sum_{i=1}^{p} a_{ij}^2$, which indicates the contribution of the common factor f_j to X. The greater the value of g_i^2, the more evident the influence of this common factor f_j on X will be. In this context, the final computational result of g_i^2 can be selected as a critical index to evaluate the importance of the common factor.

4. Results

4.1. Research Process and Samples

Between May and July 2021, 100 experts from China were invited to participate in a questionnaire survey to explore the factors affecting sustainable innovation oriented toward complex product servitization. Select experts from China's aerospace manufacturing industry, large-scale electronic information manufacturing industry, and large-scale equipment manufacturing industry were contacted for opinion consultation. After three rounds of opinion consultation, expert opinions were unified and evaluated. Table 1 presents the results of the evaluations provided by these experts.

Table 1. A statistical table of the problems with sustainable innovation oriented toward complex product servitization (n = 100).

Factors	N	Min.	Max.	Mean	SD
Innovation ability inadequacy	100	4.00	5.00	4.61	0.51640
Technological R&D ability deficiency	100	3.00	5.00	4.72	0.51640
A labor-intensive production pattern	100	4.00	5.00	4.43	0.48305
Multi-aspect intellectual resource support requires improvement	100	3.00	5.00	4.34	0.51640
Production equipment not advanced enough	100	4.00	5.00	4.22	0.45618
Lack of technological product innovation	100	4.00	5.00	4.38	0.45812
Insufficient scientific research personnel	100	3.00	5.00	4.55	0.43619
Professional quality of scientific research personnel requires improvement	100	3.00	5.00	4.31	0.39178
A poor incentive system for innovation	100	4.00	5.00	4.14	0.41184
Underused scientific research power in universities	100	2.00	5.00	4.45	0.41595
Raw material quality problems	100	4.00	5.00	4.33	0.33591
Limitations of technological innovation	100	4.00	5.00	4.22	0.61851
Insufficient innovation awareness	100	4.00	5.00	4.67	0.56217
Valid N (list status)	100				

To ensure that sustainable innovation strategies are oriented toward complex product servitization, consideration must be given to its influencing factors. Through interviews, we learned that current factors influencing complex product servitization-oriented sustainable innovation were primarily manifested in 13 aspects: innovation ability inadequacy, technological R&D ability deficiency, a labor-intensive production pattern, multi-aspect intellectual resource support requiring improvement, production equipment not being sufficiently advanced, a lack of product technological innovation, insufficient scientific research personnel, professional quality of scientific research personnel requiring improvement, a poor incentive system for innovation, underused scientific research power in universities, raw material quality problems, technological innovation limitations, and insufficient innovation awareness.

4.2. Factor Analysis Based Evaluations on Influencing Factors on Complex Product Servitization-Oriented Sustainable Innovation

The factor analysis method was adopted to extract the principal factors that influence sustainable innovation oriented toward complex product servitization to clarify the primary concerns existing in such sustainable innovation. Therefore, a solid foundation is developed for formulating a sustainable innovation strategy for complex product servitization. The detailed analysis is shown in Tables 2–5.

By conducting Kaiser–Meyer–Olkin (KMO) and Bartlett's tests, the initial variables are proven to form a correlation and to be suitable for factor analysis.

Based on factor analysis, the cumulative percentage listed in Table 4 indicates that 78.620% of the problems can be interpreted using the first two factors. Thus, Factors 1 and 2 have the potential to reflect the problems in sustainable innovation oriented toward complex product servitization.

Table 2. A check analysis table based on Kaiser–Meyer–Olkin (KMO) and Bartlett's tests.

Kaiser–Meyer–Olkin test based on sampling sufficiency		0.146
Bartlett's test of sphericity	Approximate chi-squared value	176.819
	df	12
	Sig.	0.000

Table 3. Common factor variance.

	Initial Value	Value after Extraction
Innovation ability inadequacy	1.000	0.998
Technological R&D ability deficiency	1.000	0.981
A labor-intensive production pattern	1.000	0.670
Multi-aspect intellectual resource support requires improvement	1.000	0.495
Production equipment not advanced enough	1.000	0.398
Lack of technological product innovation	1.000	0.998
Insufficient scientific research personnel	1.000	0.981
Professional quality of scientific research personnel requires improvement	1.000	0.670
A poor incentive system for innovation	1.000	0.495
Underused scientific research power in universities	1.000	0.398
Raw material quality problems	1.000	0.687
Limitations of technological innovation	1.000	0.851
Insufficient innovation awareness	1.000	0.774

Note: The extraction method used was principal component analysis.

Table 4. Explained total variance.

Component	Initial Eigenvalues			Extraction Sum of Squares Loading			Rotation Sum of Squares Loading		
	In Total	% Variance Ratios	% Cumulative Percentage	In Total	% Variance Ratios	% Cumulative Percentage	In Total	% Variance Ratios	% Cumulative Percentage
1	2.009	50.236	50.236	2.009	50.236	50.236	1.746	43.650	43.650
2	1.135	28.383	78.620	1.135	28.383	78.620	1.399	34.970	78.620
3	1.265	11.251	89.871						
4	1.026	10.128	99.999						
5	2.533×10^{-5}	0.001	100.000						

Note: Principal component analysis was used for extraction.

Table 5. Component transfer matrix.

Variables	Factor 1	Factor 2
Innovation ability inadequacy	0.515	
A poor incentive system for innovation	0.758	
Limitations of technological innovation	0.748	
Insufficient innovation awareness	0.574	
Underused scientific research power in universities	0.691	
Lack of technological product innovation	0.825	
Insufficient scientific research personnel	0.714	
Professional quality of scientific research personnel requires improvement	0.665	
Raw material quality problems		0.645
Technological R&D ability deficiency		0.681
A labor-intensive production pattern		0.754
Multi-aspect intellectual resource support requires improvement		0.756
Production equipment not advanced enough		0.817

Note: The extraction method used was principal component analysis. The rotation method used was varimax rotation using Kaiser's normalization.

By virtue of factor extraction described previously, Factors 1 and 2 are eventually determined as the two principal components, namely, innovation ability inadequacy and technological R&D ability deficiency. Accordingly, the primary factors affecting complex product servitization-oriented sustainable innovation are innovation ability inadequacy and technological R&D ability deficiency. During factor analysis, principal component analysis was adopted for extraction. The aforementioned two major influencing factors were defined. Then, sustainable innovation strategies for complex product servitization were formulated according to these two factors.

5. Discussion

5.1. Typical Characteristics in the Process of Complex Product Servitization

The process of complex product service has the following typical characteristics, which need to be considered in sustainable innovation.

(1) *More complex functions*

In contrast to other products, a complex product features highly technical content, is of high value, and has a complex structure and superior functions. Thus, complex product servitization exhibits more complex functions. During complex product servitization, more advanced added services must be designed for complex products. Therefore, complicated functions are generated.

(2) *A longer value chain*

Considering that a complex product comprises numerous spare parts and is manufactured by complex processes, integrated manufacturing in a large-scale combination mode is generally adopted for its production. The complex product industry's value chain has extensive coverage and can intensively affect peripheral industries. Comparatively, because of the incorporation of service characteristics, complex product servitization presents a longer value chain.

(3) *A shorter product life cycle*

The characteristics (e.g., advanced technology, high values, and complex processes) inherent to complex products further cause them to have shorter life cycles to a certain extent [20]. Furthermore, the transformation of high and new technology and the more profound demands of market development exacerbate the reduction in the complex product's life cycle. Similarly, the characteristic of a shorter life cycle can be found in the complex product servitization model.

(4) *A more complicated innovation process*

The technological achievements of the complex product are a set of multiple, high-end, complex processes [20]. The R&D, manufacturing, and technological innovation of complex products can be considered comparatively complex processes. Fulfilling innovation is difficult. Therefore, the innovation process can be more sophisticated during the development of complex product servitization.

(5) *More difficulties in achieving innovation sustainability*

Complex product servitization-oriented innovation is involved with both complex products and servitization. In the process of technological progress, the abilities of scientific research innovation, complex process generation, sustainable corporate development, resource utilization, and environmental protection exhibit high requirements for sustainable innovation oriented toward complex product servitization. In this context, carrying out such innovations is difficult.

5.2. Influencing Factors of Service-Oriented Sustainable Innovation of Complex Products

(1) *Insufficient innovation ability*

The realization of service-oriented sustainable innovation of complex products needs to be based on good innovation ability. However, from the current situation of service-oriented sustainable innovation of complex products, there is a problem of insufficient innovation ability. Different from other manufacturing industries, complex products have rich connotation and complex production links. The whole includes technical production and service in many fields. The basis of service-oriented sustainable innovation of complex products is the innovation ability of production and service subjects. The service-oriented industrial chain of complex products is complex and high-end. In order not to be passively controlled by upstream subjects, innovation is the key to sustainable development. The lack of innovation ability will have a negative impact on the service-oriented sustainable innovation of complex products.

(2) *Lack of technology R&D capability*

The service-oriented innovation of complex products emphasizes the integration of product production and follow-up services, extends the product value chain, extends the product service and application, and excavates the value of products in many aspects. The realization of service-oriented sustainable innovation of complex products first requires that the products have sustainable development and application value, and there should be space for service-oriented development. As a complex product with complex functions and multiple links in the production chain, the technical value of the product itself and the technical value of service-oriented means development have an important impact on the service-oriented sustainability of complex products. There is a positive correlation between technology R&D capability and the service-oriented sustainable innovation of complex products. The lack of technology R&D capability will not be conducive to the service-oriented sustainable innovation of complex products.

6. Sustainable Innovation Strategies for Complex Product Servitization

6.1. Complex Product Servitization-Oriented Sustainable Innovation Strategies for Improving Innovation Ability

6.1.1. An Innovation-Driven Development Strategy

Innovation-driven development is closely associated with complex product servitization-oriented sustainable innovation. On the one hand, innovation is a crucial driving force underlying sustainable innovation oriented toward complex product servitization; and on the other hand, this process must be realized as driven by innovation.

Innovation-driven development can guarantee systematic complex product servitization-oriented sustainable innovation. To be specific, innovation-driven development comprises early stage (i.e., the discovery and creation of knowledge), intermediate (i.e., knowledge

hatching and technological pilot tests), and later (i.e., industrialization and the distributed application of knowledge innovation results) stages. At different stages, the innovation-driven development strategy plays different roles from the perspective of concrete operational subjects, fund investment, and knowledge innovation system types. Sustainable innovation oriented toward complex product servitization is characterized by the fact that productivity and knowledge innovation are its driving forces in various stages. The differences embodied in innovation-driven development strategy coincide with this characteristic of sustainable innovation. This finding suggests that the implementation of an innovation-driven development strategy is beneficial to maintain systematic, sustainable innovation oriented toward complex product servitization.

Innovation-driven development ensures the leading position of complex product servitization-oriented sustainable innovation. Highlighting all-round innovation, an innovation-driven development strategy facilitates the formation of high-grade, high-precision, and advanced industries. High-speed and high-quality development of the complex product industry can be achieved by means of innovation-driven development, which is the ultimate goal of sustainable innovation oriented toward complex product servitization. The complex product industry covers an extensive scope; thus, an innovation-driven development strategy can promote the common development of generic technology, enable innovation accomplishments to come into play in more areas, carry forward the status improvement of the product value chain, and enable a company to obtain a dominant position in the competitive market.

Innovation-driven development guarantees highly efficient complex product servitization-oriented sustainable innovation. Depending on strategic characteristics, innovation-driven development is crucial to a positive role in industrial structure adjustment. The collaborative development of knowledge innovation, technological innovation, and generic industry are major concepts conveyed by an innovation-driven development strategy. Knowledge and technological innovation can be combined with intellectual capital to boost the development of the complex product industry toward a high-end value chain. Innovation-driven development differs from conventional imitative innovation patterns. Through technology improvement and the auxiliary driving forces of elements and capital, complex product industry upgrading can be efficiently promoted.

6.1.2. A Hard Power Cultivation Strategy

Hard power is a strength that can be independently exerted during sustainable innovation oriented toward complex product servitization, involving production equipment and production resources. The essence of innovation is to improve awareness and ability. Regarding hard power cultivation for complex product servitization-oriented sustainable innovation, training scientific research personnel is one of the first priorities. An advanced scientific research team can provide momentum for sustainable innovation. Advanced production equipment must be purchased or independently developed, and product quality must be optimized to lay a material foundation for complex product servitization-oriented innovation. With hard power cultivation, enterprises can extend their scope of business longitudinally and horizontally in the field of complex product manufacturing and services. For ensuring productivity enhancement, sustainable innovation oriented toward complex product servitization may be affected. By virtue of common holistic development, sustainable innovation oriented toward complex product servitization can be promoted.

6.1.3. A Soft Power Cultivation Strategy

Soft power is a concept related to hard power; it primarily relates to the strength embodied in the formulation of economic strategy, national policy, and development tactics [16]. In the process of soft power cultivation, strong financial support should first be provided to complex product servitization-oriented sustainable innovation. As far as complex product manufacturing and services are concerned, funds are deemed as the basis for innovation. Second, policy support is provided for the foreign market devel-

opment of complex product manufacturing and services industry, acquiring innovative ideas through market exchange. Finally, merging and reorganizing enterprises should be actively promoted, thereby facilitating the realization of production-scale expansion in the complex product manufacturing and services industry based on coordinating and unifying principles. Thus, the foundation can be laid for product innovation.

6.2. A Complex Product Servitization-Oriented Sustainable Innovation Strategy for Technological R&D Ability Improvement

6.2.1. A Technological Innovation Strategy

Sustainable innovation oriented toward complex product servitization is not a simple combination of various technologies, but significantly underlines innovative upgrading at a higher level after incorporating technologies. The complex product industry is related to multiple specialties and fields; the corresponding manufacturing and service processes must abide by a core strategy of technological innovation. Based on sophisticated frontier disciplines in diverse forms and mutual cooperation in various technical fields, industrial characteristics can be used as the starting point to optimizing relevant management systems. To ensure sustainable innovation oriented toward complex product servitization, not only should technological innovation be selected as a crucial basis, constant management system optimization and unceasing management ability reinforcement should also be carried out.

6.2.2. An Integrated Outsourcing Strategy of Technological R&D Ability

The complex product manufacturing and services industry is involved with more complicated functions and a long value chain. Under these circumstances, all associations of product development, design, production, sales, and services must be mutually matched and connected. However, the division of labor based on specialization becomes more common among complex products, which must follow an integrated outsourcing strategy during technological R&D. According to a production organization mode aimed at supply chain reconstruction on the premise of improving the overall value chain, the seamless matching of technological outsourcing and supply chain contracts has the potential to boost the improvement of system capacity for the technological R&D supply chain. In this way, sustainable innovation can be further promoted [13].

6.2.3. An Independent Improvement Strategy of the Technological R&D Ability

The development of sustainable innovation oriented toward complex product servitization can be summarized as a process, from the imitation of popular products to the introduction of advanced technologies, and further to independent innovation [12]. Unlike other manufacturing sectors, the complex product manufacturing and services industry is concerned with multiple subjects of technological innovation, which raises a high requirement for innovation resource integration ability in this industry. On the basis of exploiting and utilizing innovation resources in the complex product manufacturing and services industry, the integration and utilization of external technological resources are of great importance. Moreover, complex product servitization-oriented sustainable innovation is a process during which the participants of technological innovation transition from the borderline to the core. Therefore, technological R&D ability should be independently improved during the process of sustainable innovation. Based on upgrading this ability, a new multi-aspect multi-layered innovation system should be constructed for the complex product manufacturing and services industry by transforming it from an import-dependent imitative industrial production to an independent technological R&D. As a result, sustainable innovation can be eventually realized for complex product servitization. Lastly, an innovation network focusing on independence should be established, and appropriate external resources should be selected and used in this network.

7. Conclusions and Prospects

7.1. Main Conclusions

The complex product manufacturing and services industry is a form of manufacturing. Different from other manufacturing patterns, it is knowledge-intensive and possesses high-end values. In the post-epidemic era, improving complex product servitization-oriented sustainable innovation ability has become a core issue that must be emphasized in many enterprises. Through factor analysis, we discovered that innovation ability inadequacy and technological R&D ability deficiency are the main problems existing in complex product servitization-oriented sustainable innovation. Considering these problems, a sustainable innovation strategy aimed at improving innovation ability should stick to innovation-driven development strategies, as well as hard and soft power cultivation. Regarding the sustainable innovation strategy targeted at technological R&D ability improvement, technological innovation strategies, integrated outsourcing, and the independent improvement of technological R&D ability should be pursued.

7.2. Management Insights for Research

Sustainable innovation oriented toward complex product servitization has rarely been investigated in the literature. In the present study, sustainable innovation strategies for complex product servitization were explored from two perspectives—innovation ability and technological R&D ability improvement—by analyzing the main characteristics of complex product servitization. In this way, sustainable innovation strategies oriented toward complex product servitization were comprehensively analyzed to enrich the relevant research on sustainable innovation as well as provide a research direction for complex product servitization. Additionally, this new perspective on understanding complex product servitization provides a new concept for promoting its sustainable development.

7.3. Management Insights for Managers

Depending on the analysis of the factors influencing complex product servitization-oriented sustainable innovation, relevant sustainable innovation strategies are discussed in-depth in this paper. In addition, more established sustainable innovation strategies for complex product servitization are summarized, and an innovation-driven development strategy is introduced. From the perspectives of hard power, soft power, and scientific research ability cultivation, sustainable innovation strategies are elaborated, which provide comprehensive tactical concepts for complex product-oriented sustainable innovation. This study may be used for reference by corporate managers to select corresponding influencing factors as an entry point to profoundly analyze problems of complex product servitization related to sustainable innovation according to the physical truth of corporate growth. By learning from previous research achievements, complex product servitization-oriented sustainable innovation strategies that are suitable for corporate development can be generated to promote the sustainable innovation of complex product servitization.

7.4. Research Limitations and Prospects

Due to the comparatively small number of studies on complex product servitization-oriented sustainable innovation, the theoretical foundations of the present paper are not sufficiently solid. There are certain limitations on the understanding of relevant concepts and the formulation of specific sustainable innovation strategies. Moreover, both the pertinence and expandability of sustainable innovation strategies targeted at complex product servitization must be further enriched in future studies.

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Appendix A

A Questionnaire on the Factors Influencing Sustainable Innovation Oriented toward Complex Product Servitization

Respected experts:

This is a study on factors that influence sustainable innovation oriented toward complex product servitization. I hope that you can evaluate the following influencing factors according to your personal experience. The questionnaire is ONLY used for this research. Thanks for your help!

Please check "√" below an option that conforms to your actual situation.

Table A1. A Questionnaire on the Factors Influencing Sustainable Innovation Oriented to-ward Complex Product Servitization.

Influencing Factors	Totally Agree	Very Much Agree	Agree	Disagree	Highly Disagree
Innovation ability inadequacy					
Technological R&D ability deficiency					
A labor-intensive production pattern					
Multi-aspect intellectual resource support requires improvement					
Production equipment not advanced enough					
Lack of technological product innovation					
Insufficient scientific research personnel					
Professional quality of scientific research personnel requires improvement					
A poor incentive system for innovation					
Underused scientific research power in universities					
Raw material quality problems					
Limitations of technological innovation					
Insufficient innovation awareness					

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