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On the Collaborative Production Mode of Equipment Manufacturing Industry During the Transition to Service-Oriented Manufacturing

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Abstract: With the approaching of 'Big Data Era', traditional manufacture industry, which mainly focuses on production, can no longer satisfy the requirement of the tide. The appearance of some new ideas, such as the concept 'Industry 4.0' raised by Germany and the project 'Made in China 2025' raised by China, quickens the pace of the transformation of traditional manufacture industry which targets at the form of Service-Oriented Manufacturing. During the transformation, Collaborative Production Commerce is playing more and more important role. Based on the reality of equipment manufacturing industry, the paper analyzes the opportunities and challenges of establishing a Collaborative Manufacture System in the background of Internet Era. By analyzing the extra revenue and cost of a CMS in comparation with a simple set of entities, we draw the conclusion that the establishment is economical. By forming the mathematical model of the economy analysis of CMS, we can view and judge the CMS related matters in a more objective way and provide more figurative decision basis for the enterprises in need.

Keywords: Service-Oriented Manufacturing; Equipment Manufacturing Industry; CPC(Collaborative Production Commerce); CMS(Collaborative Manufacture System); Analysis of Economy

1 Introduction

In the 21st century, with the development of Internet and information technology and the arrival of big data era, traditional manufacturing industry which is based on production can't meet the requirement of the times any more. Therefore, Berger[1], Pappas[2] and some other scholars proposed the concept of service enhancement. According to the study of this, it was commonly ought that production service can promote the growth of manufacturing industry and the combination of production and service is a new trend of industry growth[3-4]. If traditional manufacturing industry does not want to be in the downside of the value chain, numbers of enterprises need to collaborate and update

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intellectually to make more profit.

Manufacturing industry is very important to a country, so we can improve the overall national strength by improving the productivity and competitiveness of the manufacturing industry. Collaborative Production Commerce (CPC) is an innovation mode which can help manufacturing industry increase enterprise competitiveness and decrease production cost. Therefore, studying transition mode of manufacturing industry is very meaningful to develop a country.

Service-oriented manufacturing is not only an excessive way to transmit from manufacturing industry to service industry, but also a method to attempt to increase the profit of manufacturing industry. It can improve the present manufacturing situation which has the false cost advantage and protect the environment which is consumed and polluted by extensive production and manufacturing industry transition[5]. CPC is a new manufacturing mode extended from service production. From this, it is certain that equipment manufacturing industry would come across many problems as a typical kind of traditional manufacturing industry. In the present, there is a very huge gap among the equipment manufacturing enterprises where leading enterprises have reached or even broken through the global advanced level and approached Industry 4.0 while some other backward equipment manufacturing enterprises which are still in the level of Industry 1.5 or even 1.0 gain little market space by employing large numbers of cheap labor. In addition, these enterprises tend to be in the same industry chain, so some backward enterprises may limit the development of others. Therefore, how to make full use of the comparative advantage of the leading equipment manufacturing industry to drive the backward enterprises to develop together is a serious problem that we have to face and solve to develop equipment manufacturing industry in our country.

This paper conduct a specific, comprehensive and systematic research of equipment manufacturing industry about the concept and mode of CMS under the trend of service manufacturing. We mainly use management technology based on the concept of service manufacturing, CMS, lean production to consider the change of operation mode, earnings and cost when enterprises carry out CMS on a micro level. Enterprises can decide whether to carry out CMS by thinking about building a CMS earning model of equipment manufacturing industry. This research provides a new idea for transition of equipment manufacturing industry and provides a new view for study about service manufacturing and CQM.

2 Basic concept

2.1 Service-oriented manufacturing

Service manufacturing is a new industry form and a kind of leading manufacturing mode that combines production and service. Service manufacturing is a manufacturing mode to realize value increase of members of manufacturing value chain.and at the same time to integrate distributed resources and highly collaborate their own competitiveness. It is the service based on manufacturing and at the same time, it is also the production for service [6].

In this paper, service manufacturing mainly represents that enterprises provide

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productive service and service production for each other. Productive service here is extensive service which is provided from one node to following ones. And the service production here is a production mode where enterprises have fine cooperation and mutual service in all production flow.

2.2 CPC and CMS

2.2.1 CPC

Collaborative Production Commerce referred to as CPC. The definition of CPC is a mode that makes full use of network technique and information technology which is characterized as Internet technology to realize the cooperation of product design, manufacturing, management and business inside supply chain and across chains so as to make full use of resources by changing operation mode and method.

Realizing CPC means that enterprises in the same industry chain integrate and depend on each other to a certain extent. The scholar D·J·Bowersox in the US thinks that it is possible to build the relationship of cooperation if enterprises in a industry chain admit the interdependence. Interdependence drives the desire of the functional integration, key information sharing and collaborative operation[7].

2.2.2 CMS

We need related carrier to realize the Collaborative Manufacturing System (CMS). To make it more convenient, we consider the carrier of CPC as CMS and determine the following definition:

CMS is a complete system that made up of each individual and individual collection which take part in CPC in one CPC practice. Each member of the system and each group which has inseparable property is the branch of the system. In terms of the input, the production capacity of CMS is the sum of all input of all subsystem production capacity, and the input of funds flow is the sum of input of subsystem funds flow in the creation process of CPC. The input of information is intersection of all subsystem information input. In terms of output, CMS output is more than the sum of all the subsystem output and the goal of CMS is opposite to that of subsystem, but sometimes they are coincident.

2.3 Equipment manufacturing industry

Equipment manufacturing is an umbrella term of kinds of manufacturing industry that provide equipment for national economy departments to carry out simple production and expand reproduction. Therefore it is the core of mechanical industry which takes on the responsibility to offer jobs to national economy departments and lead relative industry to develop. So, we can say that it is the heart of industry, lifeblood of national economy and cornerstone of supplying comprehensive national power[8]. Su Bo, the vice-minister of industry and information department, said, ‘from economic powers, we can see that they have powerful equipment manufacturing industry throughout their development history. So whether it is competition or economic competition among nations, in essence it is the competition of equipment manufacturing industry among nations.

Equipment manufacturing industry has three characteristics including capital intensive, labor intensive and technique intensive. The three characteristics suggest that equipment manufacturing industry needs a lot of financial, technical and labor support. At the same time, technical flow of equipment manufacturing industry is relatively more complex which needs many kinds of material and components, so it depends on other enterprises in the industry chain. Due to the same reason above, there are a lot of semi-manufactured goods in the manufacturing process. Once there are inconsistent production even serious separation in parts of industry chain, it will cause that backlog or shortage of material appears in the middle stages which will occupy cash flow and threaten the healthy operation of industry.

3 Analysis for the Benefits of CMS

3.1 Extra performance outcome beyond linear addition of each subsystem

When it comes to the operating method of CMS, a 'Competing-Cooperating-Coordinating' model is aimed to be created, which marks a significant difference between the management of CMS and that of ordinary manufacturing firms.

Considering that each subsystem of CMS has its own separating target, everyone of them wants to occupy a dominating status in the CMS and be more powerful in the distribution of the total interest. Therefore, before reaching a dynamical balance, all the subsystems will be having competitions with each other based on their own comparative advantage.

However, because of the rationality in CMS itself, which means to each certain subsystem, the price it pays for a divorce is usually higher the benefits from the divorce during the steady existence of the CMS, the inevitable consequence of the competitions will be a situation where every single item or process will be realized by the subsystem who has related comparative advantage instead of the collapse of the CMS. Overall, the operation of CMS is a cooperative process with efficiency caused by division of task, through which the best allocation is reached inside.

When the outside circumstance of CMS changes or the situation of comparative advantages alters through the development, progress or transition of the subsystems, the original balance will be broken. Before the form of a new dynamic balance, each subsystem will again have the passion for competing with each other to get a dominate status. However, a mature CMS usually have an inside mechanism for coordinating, which can help the new dynamic balance to realize by the most steady and economical way, which is very important nowadays.

Thus, rather than a set of entities, a CMS decrease the price each entity pays for its weak items or process and make it possible to maximize limited resources, which make the performance level of a CMS better than each of its entity. As a result, the whole performance of a CMS is higher than the summation of its entities.

If to a certain performance outcome Y, C0 was the summation of the price among all the entities of a potential CMS, Cc is the price a CMS pays for Y, α_{ij} and β_{ij} are the percentage of item(or process) i carried by subsystem j, S_{ij} and W_{ij} are the price the subsystem j pay for its strong/weak item(or process) i, V_i is the average price for carrying item(or process) **i** among all the subsystems :

$$C_0 = \sum_{j=1} \left(\sum_{i=1} S_{ij} \cdot \alpha_{ij} \cdot Y + \sum_{i=1} W_{ij} \cdot \alpha_{ij} \cdot Y \right)$$

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$$C_C = \sum_{j=1}\sum_{i=1} S_{ij} \cdot \beta_{ij} \cdot Y \qquad \begin{cases} S_{ij} \le V_i ; W_{ij} \ge V_i \quad \text{or} \quad W_{ij} = 0; S_{ij} \cdot W_{ij} = 0 \\ \sum a_{ij} = 1; \sum \beta_{ij} = 1 \end{cases}$$

Obviously, $C_0 > Cc$, which means for a certain performance Y, a CMS pays for less cost. Therefore, with a certain cost C, the summation of the performance among all the entities of a potential CMS Y_0 is lower than Yc, the performance of the whole CMS. And ΔY, the difference of the two, is a function of S_{ij} and W_{ij} . Thus, the first benefit of CMS can be described as $R_1 = \Delta Y(S_{ij}, W_{ij})$.

3.2 Synergy effects created by CMS

3.2.1 Brief description

The Synergetics Theory argues that synergy effects means the joint and united functions of the whole CMS caused by the collaborative behavior among all the subsystems of CMS, which are beyond the functions of each single subsystem[9]. For the Manufacturing Industry, especially the Equipment Manufacturing Industry which has a large and complex system, the positive synergy effects mainly include these below.

3.2.2 Creation of management synergy

Management synergy originally means by enterprise mergers and acquisitions, a transfer of management ability occurs among enterprises with different management abilities, which can reinforce the enterprises in need with management resources and thus result in the increase of the efficiency of assets management and the more effective distribution and usage of resources and management ability. However, mergers and acquisitions are strategic decisions with high risks and costs which can even bring about side effects beyond control. That means most middle and small-sized enterprises will seldom use M&A, and big firms also apply M&A as its daily operating method.

But with a significant improve of performance mentioned above, management synergy can never be ignored so that it need another way to be realized among potential enterprises.

CMS, which has both the form of system and the relatively independent characteristics of each subsystem, can be used to realize management synergy in that the transfer of management ability is actually created during its operation process, along with the decreased costs.

Let M_{ij} be the management cost for each management item of each CMS component entity with a certain management ability level. Here are the expressions $\mathbf{M_0}$, the total management cost before the establishment of a CMS and **Mc**, the total management cost after that:

$$M_0 = \sum M_{ij}$$

$$\text{Mc} = \sum_{i=1} j \cdot \min_i M_{ij}$$

Obviously, $Mc < M0$, which means a decrease of management cost after the establishment of a CMS. Therefore, the second benefit of CMS can be described as $R_2 = \Delta M(M_{ij})$.

3.2.3 Decrease on risk preparation

During the statement of the passage, each subsystem is making forecasts. The forecast means the awareness of changes: their reasons, regulations, situations and results. Considering that the changes are kind of uncertain, the forecast can never be exact and sometimes it is even miles away from the truth in the future[10].

Before forming a CMS, each entity of a certain industry chain has its separated value-added process, which means they need to face the risk of an unsteady supply of upstream suppliers and an unsteady demand of downstream customers on their own. Therefore, they adopt their own prevention methods which increase the precision of forecasts by improving measures of prediction or ensure the stability and the continuity of manufacturing and minimize the risks of shortage punishment by setting safety stocks for both materials and products. The disadvantages of those methods is in that if we view all these entities as a set, the forecasts operated by its subsets are largely repetitive and redundant, which are just waste of funds. Meanwhile, the large quantity of safety stocks takes up lots of working capital with warehouse costs added. The existence of those phenomena takes up and thus wastes respective sum of funds, which decrease the competitiveness of enterprise.

By contrast, entities in a CMS enjoy the highly shared information and the coordinated pace of manufacturing, which decrease the uncertainty and reduce or even eliminate the forecasts needed between each two subsystems of the CMS and the safety stocks for preventing the uncertainty. In the most ideal situation, the whole CMS only needs to respond to the change in the original material suppliers and the final customers, as well as predict and respond to the systemic risk in existence, which means a sharp decrease of the funds used for risk prevention.

Let **σ** be the systemic risk level of the industry chain, **N_j** be the location of entity **j** in the structure of the industry chain, **Ω** be the magnification coefficient of systemic risk during its conduction. Let us use **$F_j(x)$** and **$SS_j(x)$** to describe the each entity's cost of forecasts and safety stocks for responding to the systemic risk. Here are the expressions of the total cost of the CMS before(**B_0**) and after(**Bc**) its establishment:

$$B_0 = \sum_{j=1} F_j\left(\sigma^{\Omega \cdot N_j}\right) + SS_j\left(\sigma^{\Omega \cdot N_j}\right)$$

$$\mathrm{Bc} = \mathrm{F}(\sigma) + SS(\sigma)$$

Obviously **B_0<Bc**. Therefore, the third benefit of CMS can be described as **$R_3=\Delta B(\sigma,N_j,\Omega)$.**

3.2.4 Creating economy of scope

Economy of scope originally means that causing the decrease of unit cost by expanding business scope or enlarging the variety of products.

Before the establishment of a CMS, each entity has relatively limited resources, items

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and approaches available. Viewing these entities as a set, the benefits of using their limited resources, items and approaches should be linear added, as well as the costs of maintaining those. However, when a CMS is formed, the resources, items and approaches available can integrate organically and thus create the economy of scope. Meanwhile, these resources, items and approaches are becoming complementary and concordant after the integration, which can result in more benefits by the effect of '1+1＞2'.

Considering that the level of economy of scope mainly depends on the level of the scope, we use γ to describe the transverse scope of the whole CMS, use **Sp(x)** to describe the function of economy of scope. Now the fourth benefit of CMS can be described as $\mathbf{R_4=Sp(\gamma)}$.

3.2.5 Creating economy of scale

Economy of scale originally describes the benefits of mass production, which means within a certain range, the average cost decreases continuously as the scale increases[11].

Each subsystem usually has similar demand of certain materials, techniques and facilities, which can be containerized in order to realize the economy of scale and decrease the total costs by purchasing, transporting and manufacturing at an economical batch.

Considering that the level of economy of scale mainly depends on the level of the scale, we use ε_i to describe the scale of each item which forms a certain scale within the whole CMS, use **Sl(x)** to describe the function of economy of scale. Now the fifth benefit of CMS can be described as $R_5 = \sum Sl(\varepsilon_i)$.

3.3 Better reactiveness and flexibility of CMS

In traditional industry chains, downstream entities which are closer to terminal customers are more sensitive to the changes in market demands of the products but duller to the changes in supply of materials, while upstream entities which are closer to original supplier are quite the opposite. Thus each entity of the chain usually have inaccurate forecasts of procurement and sales caused by the lagging information, which usually result in the excess or insufficient procurement or production from time to time. What's worse, each entity's behavior of maximizing the consumption of stocks and the transfer of risks also adds to the hysteresis of the chain.

While in a CMS, because of the completely sharing of information, changes in the original supply and the terminal demand can be acquired by every subsystem quickly without distortion. As a result, the CMS can respond to these changes as a whole. Thanks to the quick responding, each subsystem reduces the useless storage of products and avoids the hysteresis caused by risk transfer. Therefore, CMS has better reactiveness.

In addition, because of equipping with functions and strengths of every subsystem, the CMS can easily cover the adjustments in the variety and scale of production caused by outside factors. It can respond immediately after a new dynamic balance reached via the mechanism inside, Therefore, CMS has better flexibility.

So far as we know, to an industry chain which has already formed a cooperating model of supply chain, the revenue caused by the level of reactiveness to the outside changes is a function which has a negative correlation with the time of responding while the time of responding has a negative correlation with the level of the CMS's consistency($\boldsymbol{\delta}$). So we can use a function $\mathbf{g}(\boldsymbol{\delta})$ to describe the relationship between the revenue caused by the level of reactiveness and $\boldsymbol{\delta}$, the level of the CMS's consistency. And obviously, the revenue caused by flexibility has a positive correlation with flexibility itself while the flexibility has a positive correlation with **γ**, the transverse scope of the whole CMS. So we can use **f(γ)** ,a function of **γ**, the CMS's transverse scope, to describe the revenue caused by flexibility.Therefore, the sixth benefit of CMS can be described as $\mathbf{R_6 = g(\delta) + f(\gamma)}$.

4 Analysis for the extra costs of CMS

4.1 Challenges faced during the realization of CMS

4.1.1 Limited Internet technology

There exists network delay. The quick development of Internet technology brings about convenience for transmission of information, which makes some companies even building up intranets inside to realize the coordinated operation. However, there are always different communication companies who use different networks, which causes huge troubles when a cross information transmission takes place, Cross-regional transmission and cross-national ones also have similar problems.

There exists speed limit. MOD and CAD are both excellent 3-D software in widespread use when it comes to the design of products and its routing. The realization of CMS needs the sharing of those information, which usually can pile up to hundreds of GB. Ordinary network can hardly support this kind of data transmission.

4.1.2 Diverse design languages

The so-called 'design language' not only means designing the format of data or designing relative tools, it means designing the relationship among data as well. For example, the related file of a part model is more than a 3-D model file--it is the mixture of feature attributes information, structure information, routing information, assembling information, size and tolerance information, material information and supplier information. All the entities in the CMS must acquire a united design language, or the coordination will end up in failure. Few enterprises can realize this point now.

4.1.3 Large and complex data package

For a certain product, all its data packages can form a large ocean of data. Without organizing, sorting and highlighting, these data packages will cost much time and labor to handle if they are passed to another subsystem in the CMS directly. Much related work is seriously needed to improve the situation.

4.1.4 Greatly-varied conditions among entities

The cost of the establishment of a CMS is relatively high for some companies of medium and small size, which obstructs them from participation. The gap of consciousness also acts as an obstacle.

And even for those who have formed a CMS, the level of collaborative work also varies. An ideal CMS covers the design, the manufacture and the logistics of a product, which means any nonstandard operation will affect the ordinary work of the CMS.

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4.2 Model of Cost based on Challenges

4.2.1 Synergetic Net

Synergetic net means a sharing network platform where each subsystem can use the same Internet service provider or build up fiber-optic intranet network for the sake of realizing the quick operation and collaborative process of information and files. With the assistance of the synergetic net, the CMS can realize the complete participation of the whole concept design, detailed design, simulative operation and routing design of a product from a remote distance. In this way, the coordination among entities can be further realized.

For a certain subsystem **j** from the CMS, the cost of owning such a network includes the cost of updating the network facilities and the related cost of labor and maintenance. Considering the different level of the existing facilities of each subsystem, the cost of updating also varies. And for the other costs, though being different between each other, they can be easily predicted or calculated. Let $\mathbf{m_j}$ be the measurement of the existing facility of the subsystem **j**, the function $\mathbf{h(m_j,k)}$ be the cost of updating(**k** represents the expected level), and $\mathbf{l_j}$ as the other costs, we can get the expression of the network cost for subsystem **j** as below:

$$C_j=h(m_j,k)+l_j$$

The cost for each subsystem is independent, so we can use linear addition to acquire the total network cost of a CMS:

$$C_1=\sum_{j=1}^{n} c_j=\sum_{j=1}^{n} h(m_j,k)+\sum_{j=1}^{n} l_j .$$

4.2.2 Standardizing and uniting

Standardizing tools, such as CAD and MBD, can be brought in when setting a standard series of language, indicators and parameters. The costs is not only limited within the procurement of those tools, but also covers the related labor cost, hardware cost and following cost. The procurement of those tools is considered as a behavior of the whole CMS, and there is no need in swearing apart. Let **b** be such a cost. The other costs are related to each single subsystem and can then be linear added. For a certain subsystem **j**, let $\mathbf{d_j}$ be the related labor cost, $\mathbf{e_j}$ be the related hardware cost, $\mathbf{g_j}$ be the following cost. So the total cost of this section (for the whole CMS) can be described this way:

$$C_2=b+\sum_{j=1}^{n} d_j+\sum_{j=1}^{n} e_j+\sum_{j=1}^{n} g_j .$$

4.2.3 Summary

After calculating all these extra costs of realizing a CMS, we can add the two above to acquire the final model of cost.

$$C=C_1+C_2=\sum_{j=1}^{n} c_j=\sum_{j=1}^{n} h(m_j,k)+\sum_{j=1}^{n} l_j+b+\sum_{j=1}^{n} d_j+\sum_{j=1}^{n} e_j+\sum_{j=1}^{n} g_j$$

5 Economic model of CMS in equipment manufacturing industry Chain

5.1 Basic idea

When we analyze CMS of equipment manufacturing chain, it is possible for CMS to cause positive changes and reverse changes of earnings and cost in terms of each subsystem of CMS. if $\Delta X>0$, it can save cost and increase profit in general when using CMS and vice versa. And it is very clear to know which factors influence the value of ΔX. So, we can get the following model expression:

$$\begin{aligned}\Delta X &= R_1 + R_2 + R_3 + R_4 + R_5 + R_6 - C_1 - C_2 \\ &= \Delta Y\left(S_{ij}\cdot W_{ij}\right) + \Delta M\left(M_{ij}\right) + \Delta B\left(\sigma, N_j, \Omega\right) + Sp(\gamma) + \sum Sl(\varepsilon_i) + g(\sigma) + f(\gamma) \\ &\quad - \left(\sum_{i=1}^{j} f(m_i,k) + \sum_{i=1}^{j} n_i \sum_{i=1}^{j} f(m_i,k) + \sum_{i=1}^{j} n_i\right) - \left(b + \sum_{i=1}^{j} d_i + \sum_{i=1}^{j} e_i + \sum_{i=1}^{j} g_i \sum_{i=1}^{j} d_i + \sum_{i=1}^{j} e_i + \sum_{i=1}^{j} g_i\right)\end{aligned}$$

5.2 Model analysis

We have already reached basic functional expressions above which is made up of parameters which is used to describe CMS or some qualities of each subsystem and abstract function which can measure these indicators.

Moreover, through the above analysis, it is not difficult to see that all the abstract functions affected by the parameters related to the attributes of the whole CMS are monotonically increasing, that is, when the performance of the CMS is better, the values of these functions are taken. The greater will be, the greater the benefits of implementing a CMS (without considering other items).

Among other items, only $\sum_{i=1}^{j} f(m_i,k) + \sum_{i=1}^{j} n_i$ this one will monotonously decrease the performance of the system. Therefore, how to determine the level of information facilities of the entire CMS to achieve minimum investment and maximize output will be a question worth studying.

In addition, the influence of these parameters on the value of ΔX is not equal. These parameters can be roughly divided into the parameter indexes related to the overall attributes of the entire CMS and the parameter indexes related to the individual attributes of each subsystem. The following parameters is shown as table 1.

Of course, the above expression is only a more objective description of the relationship between the last ΔX and each parameter, in order to judge what factors will be related to the implementation of the CMS. Even if the scope is delineated in the equipment manufacturing industry, the situation between different industrial chains may be very different, so the expression of each abstract function in the formula will also be different.

However, the relatively good thing is that all negative items are actually relatively predictable and controllable, and they can have schedule and budget before deciding whether to form a CMS.

As for the former part, although it is difficult to make quantitative calculations, it is not difficult to observe that in the transition from manufacturing to service-oriented manufacturing, CPC will play an increasingly important role. Therefore, from a strategic perspective, competitive

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equipment manufacturing enterprises should observe and summarize the experiences of peers, combine their own reality, establish more accurate models as far as possible to measure the former, and finally formulate targeted and rational scientific CMS implementation program.

Table 1. Influence of these parameters

Parameter Type	Parameter		Meanings
System parameters	Σ	$\sigma>0$	Systematic risk across the entire industrial chain (including changes in demand for end-products, changes in supply of raw materials at the beginning, and other factors that may cause changes in the production and operation of the equipment manufacturing industry)
	Ω	$\Omega>1$	The degree to which system risks are amplified step by step
	Γ	$\gamma>0$	Horizontal range of the entire CMS
	ε_i	$\varepsilon_i>0$	The scale of each scaled economy in the entire CMS
	Δ		CMS Synchronization Level
Single parameter	m_j	$m_j>0$	Enterprise's existing network level
	l_j	$L_j>0$	Labor costs, maintenance costs, etc. brought about by the upgrade
	B	$b>0$	Purchase cost of tools
	d_j	$d_j>0$	The cost of specialized personnel involved in the introduction of new tools
	e_j	$e_j>0$	Hardware costs for equipment, supplies, etc. purchased for the implementation of new systems
	g_j	$g_j>0$	Subsequent costs such as maintenance fees and update fees required after the new tool is applied
	S_{ij}	$S_{ij}\geq 0$; $S_{ij}\cdot W_{ij}=0$	The cost when the i project (process) is assumed by the j subsystem with comparative advantage
	W_{ij}	$W_{ij}\geq 0$; $S_{ij}\cdot W_{ij}=0$	The cost when the i project (process) is assumed by the jth subsystem with comparative disadvantage
	M_{ij}	$M_{ij}>0$	Subsystem j's management costs for managing transaction item i
	N_j	$N_j\in R^+$	The rank of the j-th subsystem in the entire equipment manufacturing industry chain structure

6 Conclusions and expectations

6.1 Conclusions

After modeling the economics of implementing a CMS, we have roughly arrived at a number of factors affecting economics and their impact mechanisms, which have been sorted out in the table 1.

For the main subject of our research, that is, the equipment manufacturing industry itself, because most of them adopt the “manufacturing by order” and “design by order” production models, the system risk σ of the industrial chain is a relatively low level. However, because the industry chain of the equipment manufacturing industry is complex and has many layers and is distributed in a network, the level Ω that is amplified step by step when the system risk is conducted is at a relatively large level. Therefore, the subsystems before and after the CMS are formed. Savings on risk preparation will not be underestimated. At the same time, because the product composition and product process are generally more complicated especially the manufacture of high-end equipment), every part of the industry chain often has a large demand for the basic components such as washers, nuts, and equipment manufacturing industry chain. After the implementation of the CMS, the horizontal breadth of the entire CMS and the scale of the economies(εi)of scale of the CMS, which are partially formed, are often large, which can produce considerable economies of scale and economies of scale. However, it is worth noting that because the product composition and product process are generally more complex, the required information level (coordinate k) required to achieve CPC is often higher, so the pre-investment in implementing a CMS is relatively large and enterprises may face the risk of losing everything after failure.

Therefore, in the long run, the implementation of a CMS will undoubtedly have a far-reaching impact and strategic significance on the equipment manufacturing industry. However, how to steadily push forward the implementation should be led by companies with a relatively central position in the equipment manufacturing industry chain. After a comprehensive analysis of the current situation in the industry, it should be gradually adopted.

6.2 Follow-up research prospects

The key to CPC is the establishment of an Internet network technology platform. The economic model implemented by the CMS discussed in this paper is only from the perspective of the system to consider the changes in the effectiveness of the manufacturing enterprise after adopting the new CPC model. It does not consider the game as a single enterprise under the system of cost-benefit. From the CMS benefit model, it can be known that, after adopting CPC, the enterprise will also increase costs from the construction of the platform while receiving benefits from it. In addition, for the entire system, it also involves the distribution of profit. Therefore, for equipment manufacturing companies, whether to use CPC, how much the system costs, how much revenue can be, these are the problems of the game. However, this part is not discussed in this paper which is the inadequacy of this article, and it is also the direction that the research team hopes to follow in the future.

In addition, the research direction of this paper is to explore the implementation of CPC

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mode in the transition from equipment manufacturing to service-oriented manufacturing. However, due to limited resources, we can only conclude that after the implementation of the CMS, the response and flexibility of the supply chain of the equipment manufacturing industry have been improved, which can more effectively respond to the changing demand in the service-oriented manufacturing environment. However, whether the transition from the equipment manufacturing industry to the service-oriented manufacturing system after the implementation of the CMS will have other effects will not be realized. We need to wait until we gather more relevant materials and examples for further discussion and research.

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