Capacity Set Optimization of Knowledge-Based Enterprise and Its Organizational IQ[*]

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Abstract:　　In this paper, the knowledge-based enterprise is considered as an organism, which possesses a set of capabilities. The organizational structure model of knowledge-based enterprise organism is described in order to possess the essential capacity set. A dynamic capacity set is defined and analyzed based on the definition of the growth and development for knowledge-based enterprise organism. The structure of the capacity base, a subset of the capacity set, is optimized for different periods of the organism's lifecycle. Based on the organizational structure, the organizational IQ of knowledge-based enterprise is defined. And it is proved that the organizational IQ is increased with the improvement of the ability of sensing and reaction, and it is achieved by the adjustment of the connection weights between the intelligent units.

Key words:　　knowledge-based enterprise, capacity set, organizational IQ

Nowadays, the knowledge-based enterprise becomes the main object of management, whose main body is knowledge-based employees, which is based on obscurity asset of knowledge, intelligence and so on. The potential knowledge and the intuition experience are regarded as their strategic resources in the knowledge-based enterprises. Referring to the speed of changing in the business environment, knowledge-based enterprises have to face the opportunities and challenges of technology reform, the quick changes of customer's demands and the emergence of new competitors all the time. The lifecycle of knowledge-based enterprise is shrinking. To search for the way of having a long life and to analyze the internal mechanism of the growth and development for knowledge-based enterprise become the common concern of many scholars and entrepreneurs.

For a long time, many scholars have put forward different theories to analyze the impetus mechanism of the growth of enterprises. R. Coase, the economist of the U.S. pointed out that firms were the substitutions of price mechanism[1]. He emphasized that the basis for the choice of the firm's scale should be the transaction cost, and the growth of firms is determined by appropriate system arrangement and system innovation. Ben, the economist of the U.S. pointed out a frame of structure-action-performance in his book *Industry Structure* （1959）. He attributed the growth of enterprises to the structure of market and the enterprises' action in market. In Ref.［2］, the growth process of enterprise was investigated used the heredity, natural selection and the diversity of biology in evolutionism. The theory expatiated the accumulation process of the new competence and knowledge, and emphasized the importance of knowledge accumulation for growth of enterprises. The importance of internal resources, core technologies and skills for the growth of enterprises has been further emphasized in the competence theory of the firm set up later[3]. The theory tried to substitute the structure-action-performance frame of the traditional theory of firms. It was also the substitution or supplement of the theory represented by Michael E Porter, which is based on the frame of industry analysis to explain the growth of enterprises[4].

In this paper, the internal mechanism of growth and development of knowledge-based enterprises are discussed and analyzed based on the system theory and the competence theory. The organizational structure model of knowledge-based enterprise organism is proposed, considering the characters of the knowledge-based enterprise.

1 Organizational Structure of Knowledge-Based Enterprise Organism and System Theory's View of Its Growth and Development

1.1 Definition and organizational structure of knowledge-based enterprise organism

Natural organisms all have the lifecycle of birth, growth, wane and death. So do enterprises. All enterprises have the periods of gestation, babyhood,

adolescence, mature, wane and death[5]. But, different to organisms in nature, the lifecycle of enterprises varies depending on their competitive capability. Effective management mechanism can prolong the enterprise's lifecycle.

The main body of knowledge-based enterprises is knowledge-based employees. The main resource of such enterprises is the intelligence and knowledge of their employees. Be in the society composed of high intelligent human, the knowledge-based enterprises should not be a machine for producing products or earning profit, but should be a living organic whole[5]. Such whole has the function of self-organization, self-evolution, and the capacity to sense and diagnose its own health. Profit for the knowledge-based enterprises is the same as oxygen for the human being. It is only the necessary condition for living, not the goal of living. Besides living, knowledge-based enterprises also have the security demand to be prevented from injury, the social demand to be accepted by public, the different demand to be respected by others, and the self-realized demand to exert potential power and realize ideals. So, knowledge-based enterprises are not only the tools for people to pursue profits, but also living organisms, which have their own characters, demands, goals, and metastasis function for living and permanent development.

Knowledge-based enterprise organism lives in a complex, changing and highly competitive environment, which is similar to human beings', so they should have the keen sense or even specific the 6th feeling, intuition, towards the variable environment[6]. They should have the flexibility of acclimation, the learning ability to improve its own intelligence. The organism's capacities of sense and reaction are the enterprises' driving power of their growth and development. To possess sense and reaction capacity, the knowledge-based enterprise organism should adjust its direction function during its lifecycle. All these require the knowledge-based enterprise organism to have the living, purposeful and quick reaction ability similar to human beings'. However, there are many factors affecting the knowledge-based enterprise organism's sensing and reaction ability, the most important one is the organizational structure of the knowledge-based enterprise organism.

After millions of years of evolution, human beings have the capacities of keen sense, adaptability and learning ability, which are based on their highly developed brain. The information transaction system of human brain can provide suggestions to optimize the structure of knowledge-based enterprise organism.

The neural system of human brain is a stratified, multi-unit and dynamic information processing system. The input information of sensing organs is transferred to the brain by the means of cluster or parallel connection. And finally, the acting organs control the body to make suitable reaction to the environment.

Its mechanism has the following characteristics:

1) Information is stored and processed by the neural cells in distributing and parallel manner. The structure of every cell is simple.

2) With self-organization and self-learning ability, the neural network of human being can adjust the connection intensity and reorganize the mutual relation between neural cells based on the input information, so as to fit for the environment.

In order to have the capacities of quick sensing and reaction to the living environment similar to human beings', knowledge-based enterprise should be an organism composed of central intelligent decision units and intelligent units. The central intelligent decision unit comprises knowledge-based employees and experts. It mainly plays the role of coordinator and strategic decision maker. The intelligent units are the sensors to detect the changes of the living environment. They will make the decision whether the information should be transferred to other intelligent units and central intelligent decision unit or not. Similar to the neural cells in the human being's brain, there are connections between every intelligent unit and the central decision unit comprising the organism, and all the units are connected by parallel or cluster manners. They have the capability to process information and knowledge. Meanwhile, knowledge-based enterprise organism is an open self-organization. In order to have the ability of keen sense and quick reaction to living environment changes, every existence unit can connect or disconnect between each other at any time accompanied with the demands of its development. Then the knowledge-based enterprise organism can be made an organized but non-structured organism. The structure model is shown in Fig.1.

During the period of living and developing of knowledge-based enterprise organism, the organization structure can keep dynamic and consistent changes in order to possess the capacities of keen sense and quick reaction desired by the permanent development of organism. As the number of organism's intelligent units and the relationship between intelligent units are varied dynamically, the structural model shown in Fig.1 is called general structure model.
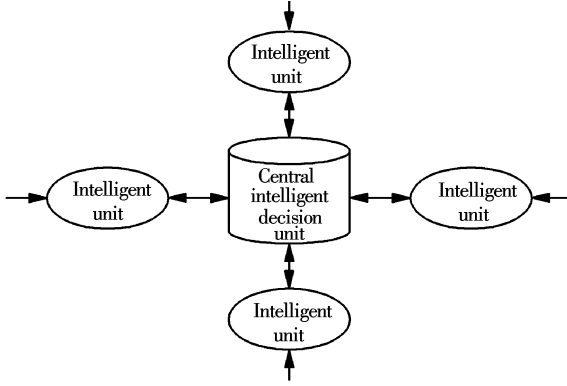
Fig.1　The general structure model

1.2　System theory's view of knowledge-based enterprise organism's growth and development

Knowledge-based enterprise organism has a development process from small to big and from weak to strong. In order to discuss the internal impetus mechanism of the organism, the definition and meaning of organism's growth and development are given from the viewpoint of system theory.

System is a whole composed of many inter-related parts to achieve special functions. Enterprise is an open system inter-affected with other bodies in its living environment. An open system is composed of three parts: input, conversion process and output[7]. And it can be described by $y = T(X)$. The conversion process T is called conversion operator set. It can also be understood as result = capacity × reason. So, T is also called capacity set, which is composed of different kinds of abilities of the system. Meanwhile, a system is also defined as a set of elements inter-related according to some characters. While the amount, the conversion capacities, and the inter-relationship of the system elements (viz. the structure of system) are different, the characters of the systems are not the same. According to Bertalanffy's definition, what is called the growth of system is the equal-result changes of the system itself, which is not consistent with initial stages and nonreversible through composing and destroying components by the system itself. H.G.Hicks defined later that growth and development of the system commonly could be considered as enlarged in scale or improved in achievement. He also said what was called the growth of organization was reorganizing of resources and setting of a new ideal goal, which was possible and realistic[8]. The growth and development that Hicks called included the changes of structure and capacity set of system.

The knowledge-based enterprise organism has its own demand and development goal with individual character. When its development goal was consistent with its outside society's development goal, it can develop acclimatizing with the society. The development direction function of knowledge-based enterprise organism is denoted as $\hat{X}_t$, and the development direction function of the society is denoted as $\hat{S}_t$, $\hat{X}_t = f(y_{1,t}, y_{2,t}, \cdots, y_{n,t})$, where $y_{i,t}$ ($i = 1, 2, \cdots, n$) is substantial or non-substantial output to determine the precedence of knowledge-based enterprise organism in the industry ecosystem at the time of t. $Y_t = (y_{1,t}, y_{2,t}, \cdots, y_{n,t})$, which is the output at the time of t, affected by capacity set T_t, and with the input $X(T_t$ is the capacity set of knowledge-based enterprise organism at the time of t). So, we have the definitions below.

Definition 1　For the knowledge-based enterprise organism S, if $\lim_{t \to \infty} \{ Y_t - \hat{X}_t \} = 0, \lim_{t \to \infty} \{ \hat{X}_t - \hat{S}_t \} = 0$ and $y_{i,t} \leqslant y_{i,t+1}$, $y_{i,t}$ is some kinds of output of S, and there exists at least t_0, satisfied $y_{i,t_0} < y_{i,t_0+1}$, then S is called stable growth for any t.

Definition 2　For knowledge-based enterprise organism S, if $\lim_{t \to \infty} \{ Y_t - \hat{X}_t \} = 0$, $\lim_{t \to \infty} \{ \hat{X}_t - \hat{S}_t \} = 0$, $\forall t$, when the system input is X, there are $T_{t+1}(X) \geqslant T_t(X)$, then S is called development.

It is shown in definition 1 that when the direction function of knowledge-based enterprise organism S with the outside society direction function $\hat{S}_t$ is consistent, and when the output of S is consistent with its own direction function, the quantitative change (principally enlarging in scale) of systematic output $y_{i,t}$ with some character i based on the corresponded goal is then called stable growth. And when the quantitative changes of the output of S are achieved accompanied with the transform of the capacity set T, the changes are called development.

2　Constitutes of Capacity Base of Knowledge-Based Enterprise Organism's Capacity Set T

Definition 3　For any set A, A^* is called the base of A. If and only if for any $x \in A^*$, there is $x \in A$, and for any element $a \in A$, a can be formed on the basis of A^*.

In order to keep permanent development, knowledge-based organisms not only should have the quick emergency reflection capacity to adapt to its variation living environment, but also should create suitable living environment. That means by changing the system's capacity set T and its direction function $\hat{X}_t$, the organism can purposefully adjust or change its environment and even the social direction function.

So, it is essential to have a dynamic capacity set T suitable for its living goals in the process of growth and persistent development. T is an integrated structure system composed by various capacities. There exists $T_B \subset T$, such that every capacity's lose of T_B will lead to bugs and problems during its growth and development. So, T_B is called the capacity base of T. The structure of T_B is discussed below.

2.1 Capacity of health diagnose and adjustment of knowledge-based enterprise organism

To satisfy the needs of living and security, knowledge-based enterprise organism should have the capacity of self-diagnose of its own internal pathological change. The pathological change of system S is denoted as $\dot{X}_t(S)$, in which $\dot{X}_t(S) = Y_t - \hat{X}_t$. It means the variance between the system's output and its direction function when the input is X. Knowledge-based enterprise organism should detect the variance $\dot{X}_t(S)$ at any time, and should have the capacity of self-restore and self-adjust the variance when $\dot{X}_t(S)$ alters in an area of R. R is called the stable area of the knowledge-based enterprise organism. When $\dot{X}_t(S)$ leaves the stable area, organisms should have the capacity to modify the $\dot{X}_t(S)$ with the help of outside force.

2.2 Capacity of integrated cooperation of knowledge-based enterprise organism

The organism of knowledge-based enterprise is composed of many subsystems. These subsystems' direction functions are not consistent with the organism S' direction function $\hat{X}_t(S)$ in general. Knowledge-based enterprise organism should have the ability to harmonize the different subsystems to make those subsystems' direction functions consistent with the one of the integrated system. Meanwhile, knowledgebased enterprise organism is an organization whose main body is knowledge-based employees. So, it should have the capacity to make all employees and all intelligent units consistent with the organism as a whole, in the terms of profits and development goals.

2.3 Capacity of management and allocation of information, knowledge, decision rights and intelligence resource of knowledge-based enterprise organism

In order to survive and develop, knowledge-based enterprises organism should have the capacity of learning, the capacity of allocation for information resource and knowledge resource. That includes aptitude allocation (allocation of the decision-making right) subject to the limited substance resource.

2.4 Sense and reaction capacity of knowledge-based enterprise organism

The knowledge-based enterprise organism can exactly evaluate and realize its position, advantages and aptitude in the whole industry ecosystem by itself. Meanwhile, it should quickly sense and react in advance of opportunities and crisis. These require the organism has the capacity of quick allocation for every kind of resource, and form capacity set T and organization structure, and even form intuition reaction.

3 Dynamic Optimization of Capacity Base T_B and the Organizational Intelligent Quotient (IQ) of Knowledge-Based Enterprise Organism

As described above, the growth and development of knowledge-based enterprise organism are determined by the transform of capacity set T, and T is based on T_B. But the constitutes of T_B described above can't hold at the same time, and these four capacities normally can't be worked harmoniously in different stages of lifecycle. So, during the lifecycle of knowledge-based enterprise organism, its capacity set T needs continuously to be reformed in order to accelerate the organism's growth and development.

In the gestation period of the organism of knowledge-based enterprises, the capacity described in section 2.4 leads a dominant position in T_B. It is because now the capacity of sensing and reaction of future market demands in advance is needed. In the babyhood, the capacity described in section 2.1 is the dominant, which means health and survival are the most important goals, while other capacities are in subordination. And now the stable area R of organism is relatively small, so a very small value of $\dot{X}_t(S)$ can result in the knowledge-based enterprise organism coming to a premature end. In the adolescence period, with the enlarged scale of organism and the expansion of resource in knowledge-based enterprise organism, the capacity of management and resource allocation is needed to improve, which means the whole cooperation capacity in T_B should be developed quickly. In the period of mature, the four capacities are developed most harmonically. The capacity described in section 2.1 is represented by the relatively larger variance stable area R, which means the organism has relatively stronger capacity of sensing and self-diagnose. Even for

the relatively large departure of $\dot{X}_t(S)$, the organism can recover in short time. Meanwhile capacity described in section 2.2 is represented by that organism has had relatively stable resource management, allocation regulations, relatively common enterprise culture and views. It also means that the capacity of whole cooperation has been developed. The capacity of sense and reaction of organism is continuously enhanced. However, it is difficult to enter the stage of mature, and it is more difficult to maintain mature stage. When the knowledge-based enterprise organism begins to lose the keenness and initiative action for the changing of outside environment in mature period, other capacities begin to depress, and it also begins to leave mature stage and enters into the stable stage. During the stable stage, capacity of quick sensing and reaction are depressed, but the whole cooperation capacity is strengthened. It can be explained by such a way that because the organism arrives at top development crest after receiving success, the drive power to strive hard for existence and development begins to depress. So, more attentions are given to the internal human relationship and enterprises' spirit. If the organism's capacity of sensing and reaction are in a low level for a long time, it will lead other capacities depress and lead the organism into the stage of waning in end. During the period of waning, generally the organism's capacity set T is in a state of logjam. Regardless of the variable environment, the growth and development of every subsystem of the knowledge-based enterprise organism are only according to the previous direction function. The capacities of health diagnosis and cooperation become weaker, and the variance stable area R is reduced, which means relatively smaller variance of $\dot{X}_t(S)$ will destroy organism. The sensing and reaction abilities are also depressed. The knowledge-based enterprise organism's direction function $\hat{X}_t(S)$ will not fit for the development of environment and society, and the direction functions of the individuals' or the subsystem's are not consistent with the whole system's. When the organism's capacity of sensing and reaction disappears, the knowledge-based enterprise organism's dying period comes around.

The capacity base is the core of the capacity set. The implementation of them is the guarantee for long living and permanent development. Aggregating the capacity set yields the organizational intelligence quotient (IQ). Similar to the natural organism, the organizational IQ is expressed by the variations of the connection weights between the intelligent units. The knowledge-based enterprise organism is denoted as O,

and it has definite states, $O = \{O_1, O_2, \cdots, O_l\}$. A *priori* knowledge of the organism about the outside environment changing is expressed by the density function $P(x)$ ($x \in S$, S is the output states space of O, $S \subset R^n$). With the conclusion of statistical mechanics[9], we have

$$P(x) = \frac{1}{\Phi} e^{-\lambda U(x)}$$

where Φ is determined by the structure of the organism, and it is called divide function; $\lambda = (\lambda_1, \lambda_2, \cdots, \lambda_m)$ is the vector of connection weights between intelligent units, $U(x) = (U_1(x), U_2(x) \cdots, U_m(x))$ is the input of O; m is the number of intelligent units. Based on its IQ and learning, the organism obtained $P_0(x)$, the estimate of $P(x)$. As the entropy is the measure of uncertainty, the obtained knowledge can be measured by the decrease of the entropy H,

$$H = -\int P(x)\ln p(x)\,dx - \left(-\int P_0(x)\ln P_0(x)\,dx\right) = \int P_0(x)\ln P_0(x)\,dx - \int P(x)\ln P(x)\,dx$$

where H is also a measure of the ability of learning of knowledge-based enterprise organism.

Definition 4 The organizational IQ of knowledge-based enterprise organism is defined as

$$IQ = \frac{dH}{d\lambda} = \left(\frac{\partial H}{\partial \lambda_1} \cdots \frac{\partial H}{\partial \lambda_m}\right)$$

where $\lambda = (\lambda_1, \lambda_2, \cdots, \lambda_m)$ is the vector of connection weights between intelligent unit; m is the number of intelligent unit.

The first sensing and reaction to the outside environment changing is expressed by $P(x)$. Then the ability of sensing and reaction of knowledge-based enterprise organism can be measured by $H(p(x))$,

$$H(P(x)) = -\int P(x)\ln P(x)\,dx.$$

Theorem 1 $H(p(x))$ increases with the improvement of IQ. Prove from definition 4, we have

$$IQ = \frac{\partial H}{\partial \lambda} \frac{\partial H}{\partial \lambda_i} =$$

$$\frac{\partial}{\partial \lambda_i}\left(\int P_0(x)\ln P_0(x)\,dx - \int P(x)\ln P(x)\,dx\right) =$$

$$-\frac{\partial}{\partial \lambda_i}\int P(x) \cdot \frac{1}{P(x)}\frac{\partial P(x)}{\partial \lambda_i}\,dx =$$

$$\frac{\partial}{\partial \lambda_i}\int P(x) \cdot \frac{1}{P(x)} \cdot \frac{1}{\Phi} \cdot$$

$$\exp\left(-\sum_i \lambda_i U_i(x)\right)U_i(x)\,dx =$$

$$\int P(x)U_i(x)\,dx = E_P(U_i(x))$$

But

$$H(P(x)) = -\int P(x)\ln P(x)\,dx =$$

$$-\int P(x)\left(-\ln\Phi - \sum_i \lambda_i U_i(x)\right)\mathrm{d}x = $$

$$\ln\Phi + \sum_{i=1}^{m}\lambda_i E_P(U_i(x))$$

Then

$$\ln\Phi = H(P(x)) - \sum_{i=1}^{m}\lambda_i \frac{\partial H(P_0, P)}{\partial \lambda_i}$$

when the organizational structure is determined, $\ln\Phi$ is a constant, and $\lambda \geqslant 0$. So when IQ $= \frac{\partial H}{\partial \lambda}$ is improved, $H(p(X))$ is increased.

The conclusion illustrates that organizational structure, especially the variation of the connection weights between the intelligent units, positively associated with capacity set. It also demonstrates that changing can make the knowledge-based enterprise organism long living and permanent development.

4 Conclusion

The knowledge-based enterprises should be an organism with capacity of quick reaction because its living environment changes all the time. From the viewpoint of the system theory, the growth and development of knowledge-based enterprise organism is defined in this paper. It is pointed out that knowledge-based enterprise organism should have dynamic capacity set consistent with the period of its lifecycle, and it is represented by the variance of the capacity base, the basis of the capacity set. The structure of the capacity base should be consistent with the development direction function of the knowledge-based enterprise organism. It was also pointed out that in order to have the desired capacity set, especially the capacity of keen sense and quick reaction, knowledge-based enterprise organism should have the structure composed of intelligence units and the central intelligent decision unit. These units can be connected or disconnected in order to realize the coupling of the information and knowledge between them, and the rate of variation of the connection weights between each intelligent unit can be used as the measurement of organizational IQ, and the ability of sensing and reaction of knowledge-based enterprise organism is increased as its IQ is improved.

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知识型企业能力集优化及其组织智商

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摘　要　知识型企业是具有动态优化能力集合的有机生命体.为具备快速应变能力,知识型企业在组织结构上应是由智能单元、中央决策智能单元通过适时、适当连接形成的动态网络.本文基于知识型企业的生存与发展的定义,给出知识型企业生命体动态优化的能力集的子集——能力基的概念,研究了能力基的动态优化过程;本文证明了知识型企业生命体智能单元间联权重的变化率——生命体智商,随知识型企业生命体应变能力的提高而提高;应变能力的提高,通过智能单元间权重的变化而实现.

关键词　知识型企业,能力集,组织 IQ

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