

PROCESS INNOVATION ORGANIZATIONAL EVOLUTION IN MANUFACTURING ENTERPRISES UNDER THE CIRCUMSTANCE OF INFORMATIONIZATION BASED ON LOTKA-VOLTERRA MODEL

^{1,2}KEXIN BI, ¹DI FENG, ¹QUANZHEN BAO

¹School of Economics & Management, Harbin Engineering University, Harbin 150001, Heilongjiang,
China

²School of Management, Harbin University of Science and Technology, Harbin 150080, Heilongjiang,
China

ABSTRACT

In order to conform to the requirements of the development of information era, the influence of informationization on innovation organization in manufacturing enterprises has gradually become the focus of the study. Based on the theory of innovation organization and organizational routine, this article summarizes process innovation organizational characteristic in manufacturing enterprises under the condition of informationization, and proposes process innovation organizational evolution mechanism in manufacturing enterprises under the condition of informationization, and constructs the Lotka-Volterra model of process innovation organizational evolution in manufacturing enterprises under the circumstance of informationization, then uses Matlab software to simulate the influence of different parameters. This article will contribute to process innovation organizational transformation and evolution in manufacturing enterprises under the condition of informationization.

Keywords: *Informationization, Manufacturing Enterprise, Process Innovation Organization, Organizational Evolution, Lotka-Volterra Model*

1. INTRODUCTION

Process innovation organization is the system composed of human and material resources which manages process innovation information[1]. The development of informationization has brought great changes for the survival and development environment of process innovation organization[2]. Under the circumstance of informationization, the development and utilization of information resources and information technology is helpful for process innovation organization to identify critical resources and develop dynamic capability, and promote process innovation organizational evolution.

Concerning study on the connotation of process innovation organizational evolution, One perspective is based on Darwin's natural selection research, which considers that the changes of external environment which brought by informationization promote process innovation organizational evolution, and complicated hypercompetitive brought by the rapid development

of information technology and the network economy puts forward severe challenges to process innovation organization, making traditional functional organization reform into flow-oriented process organization and virtual process innovation alliance[3, 4], another perspective is based on Lamarck's "use it or lose it" research, process innovation organization transforms actively in order to adapt to external environment which brought by informationization. Through the use of the new leadership and mode of resource configuration, process innovation organization restructures department and organizational strategy and so on, in order to achieve significant improvements on production process or product delivery process and adapt to the requirements of the development of informationization era[5].

For the research on content of process innovation organizational evolution, Wang Feirong, etc. hold that the development of technology innovation organization under the environment of network organization mainly displays in organizational boundary fuzzification, organizational structure flattening, and organizational process virtualization[6]. Kuntz,



etc. explains sense, interpretation, preparation and activities of process innovation organizational change in the application of information technology from individual, group and organization three aspects[7]. In further studies, process innovation organizational form in different evolution stages is studied. Richard puts forward that with the extensive application of information technology, process innovation organization evolves from traditional functional, business type, matrix organization to process model and virtual network organization[8]. O'Reilly considers that organic organization should be used in the stage of exploratory process innovation, and mechanical organization should be used in the stage of exploitative process innovation, binary process innovation organization is presented so as to adapt to the change brought by network environment [9].

For the research on course of process innovation organizational evolution, Hodgson considers that the essence of process innovation organizational evolution is variation—selection—retention, globalization and informationization in manufacturing enterprises require process innovation organization realize the process of evolution rapidly[10]. Greiner divides the process of evolution into five phases: creativity, direction, delegation, coordination and collaboration, and each evolutionary period is characterized by the dominant management problem that must be solved before growth can continue[11]. Richard supports that the widespread use of information technology and network technology, which are elements of successful transformation, improve success rates of process innovation organizational evolution[8]. Feldman, etc. and Zhanjun Gao, etc. put forward that as genes of organizational evolution, organizational routine evolves through many stages of organizational learning regression cycle, which is affected synthetically by intra- and inter-organizational stimulation and innovative information based on the existing organizational routine [12, 13].

Although the scholars at home and abroad use a variety of theory to search technology innovation organization, organizational evolution and organizational change under the condition of informationization from perspectives of the evolutionary economics, management science, sociology theory, research on technology innovation organization under the condition of information is still in the primary stage. Study on organizational evolution law under the condition of information and how informationization impact process innovation organizational development are

still in blank field. This study conforms to the requirements of the development of informationization era, which will contribute to process innovation organizational transformation and upgrade.

2. PROCESS INNOVATION ORGANIZATIONAL CHARACTERISTICS AND EVOLUTION MECHANISM UNDER THE CONDITION OF INFORMATIONIZATION

2.1 Process Innovation Organizational Characteristics under the Condition of Informationization

Adaptive process innovation organization under the condition of informationization helps managers make decision on process innovation strategy, so as to improve process innovation performance and the core competitive advantage, etc. Specific characteristics variable of process innovation organizational design is the primary premise of process innovation organizational formation. Consequently, based on the conclusion of Daft and Mazarol, this paper analyzes process innovation organizational characteristics under the condition of information from strategy, structure, process and culture four dimensions[8, 14].

2.1.1 Strategic characteristics of process innovation organization under the condition of informationization

Process innovation organizational strategy is process innovation resource allocation and behavior plan made by organization in order to adapt to the environment change and achieve organizational goals, which determines object and competitive skills of process innovation organization that differs from traditional organization[8]. With the development of informationization in manufacturing enterprises, process innovation organization faces increasingly complicated environment that diversification and individuation of market demand shortens the cycle of process development and improves the risk of process innovation[15]. Therefore, process innovation organization under the condition of informationization needs adjusting the competition strategy and making full use of critical resource advantages and gradually abandoning the traditional competitive strategy. Process innovation organization shifts from competitive strategy to cooperating strategy through cooperate with other organization innovation actively.

2.1.2 Structure characteristics of process innovation organization under the condition of informationization

Process innovation organizational structure means the structure system formed in the scope of duties, responsibilities and rights that the members develop cooperation in the course of process innovation in order to achieve the goals of process innovation, in the technology innovation process division of labor cooperation, in the subject area, responsibility and rights by the formation of the structure system. The rapid development of information and communication technology has brought increasingly fierce market competition. The traditional organizational structure bears overweight hierarchy chain load, and top management seldom responds to problem or opportunity. Therefore, process innovation organization under the condition of informationization needs flat organizational structure, through the decrease of hierarchy between the leadership and staff management and the increase of transmission speed of information resources between the superior and the subordinate managers, realizing process innovation organization shifts from vertical organizational structure to horizontal organizational structure

2.1.3 Process characteristics of process innovation organization under the condition of informationization

Process innovation organization process means a series of process innovation link or step that completes a task, event or activity of process innovation. The development of informationization in manufacturing enterprise makes information network cover the departments and position, which contributes to thoroughly redesign or improve innovation business process and realize business process reengineering of process innovation and improve information transfer speed and business process efficiency [1, 16]. Consequently, process innovation organization requires business process designing oriented by task, and simplifies workload of each section in process innovation business process, and gradually eliminates traditional business process oriented by function, realizing process innovation organization shifts from function-oriented to task-oriented .

2.1.4 Culture characteristics of process innovation organization under the condition of informationization

Process innovation organization culture is crucial component of process innovation competitive advantage, whose importance lies in the fact that it

can affect innovation behavior of research staff and function of process innovation organization without direct and imposed control[5, 17]. With the extensive application of information technology, traditional stiff process innovation organization culture cultivated in the stable environment in the past already can't adapt to the rapid change of the market demand brought about by informationization. Therefore, process innovation organization managers conduct organizational culture change on purpose, realizing process innovation organizational culture shifts from stiff to adaptive in order to meet the new requirement and implement process innovation strategy.

2.2 Process Innovation Organizational Evolution Mechanism in Manufacturing Enterprises under the Condition of Informationization

Organization is a complex system. Organizational strategy, structure, process and culture are the most important and related four variables, and any variable change will cause other variables change[8, 18]. Through the analysis of process innovation organization characteristics under the condition of informationization, it is consider that process innovation organization is evolutionary system which contains cooperative strategy, horizontal structure, task-oriented process and adaptive culture. These four elements synergy with each other under the influence of external environment, which makes the internal system produce a similar gene with transmissibility— process innovation organizational routine[19, 20]. Meanwhile, process innovation organizational routine will be embedded in a variety of organizational phenomenon after formation, which covers the organizational structure, rules, procedures, strategic, culture and many other aspects. On that basis, process innovation organization is constructed and operates[21]. As shown in Figure 1.

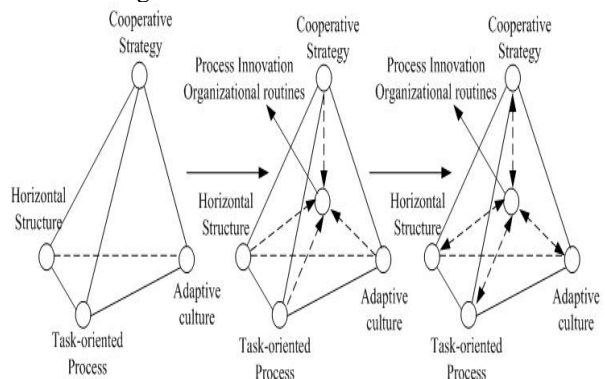


Figure 1: Process Innovation Organization System Composition Structure

From perspective of evolutionary economics, process innovation organizational evolution is interaction between hierarchy entities determined by organizational routines actually under the condition of limited resources, which is change process from traditional organizational routines to process innovation organizational routines. There are two main ways in the change of organizational routine—“search” and “create”. Search means process innovation organization looks for suitable for their needs and matches with organizational existing knowledge structure from the existing technology and routines, which are absorbed and integrated and become part of the organizational routines. Create means process innovation organization explores new technology and routines through research and development. Search and create can be achieved by organizational learning and innovation. After comparison and selection in organization, process innovation organizational routines are eventually adopted.

Under the condition of informationization, the development and utilization of information resources and information technology not only contributes to search and creation of process innovation organization routines, but also contributes to process innovation organization routines dominate on organizational strategy, structure, process and culture. Consequently, under the condition of informationization, with the evolvement of organizational routines, process innovation organization transforms from cooperating strategy, vertical organizational structure, function-oriented process, and stiff culture to competitive strategy, horizontal organizational structure, task-oriented process and adaptive culture. As shown in Figure 2.

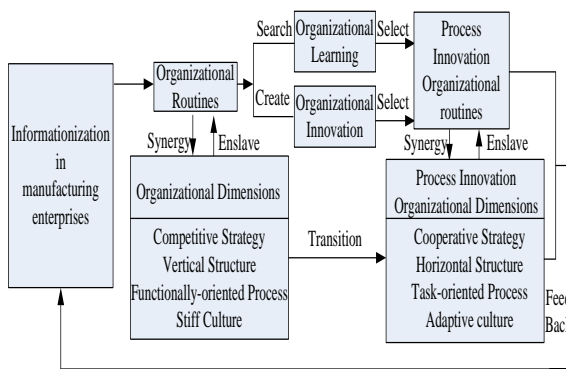


Figure 2: Formation Mechanism Of Process Innovation Under The Condition Of Informationization

3. THE LOTAKA-VOLTERRA MODEL OF PROCESS INNOVATION ORGANIATIONAL EVOLUTION IN MANUFACTURING ENTERPRISES UNDER THE CIRCUMSTANCE OF INFORMATIONIZATION

3.1 Basic Hypotheses Model Specification

Hypothesis 1 the evolution of process innovation organization is affected by itself, the potential alternative organizations and existing complementary organizations. Given the time and space, the evolution is affected by process innovation organization routines.

Hypothesis 2 the evolution of process innovation organization under the circumstance of informationization is not only affected by the information resource utilization and the information technology application, but also by the alternative and complementary effects. Affected by the alternative effect, the process innovation organization would deviate from the original evolution path and interfered by the new process innovation; affected by the complementary effect, there would be an additive effect between the process innovation organization and its' complementary organization, which can promote the evolution speed an amplitude of the process innovation organization.

Hypothesis 3 the state variables of the process innovation organization evolution can be represented by the fitness of process innovation organization, and evaluated by the aspects such as the organization strategy (Ost), organizational structure (Os), organization process(Op) and organizational culture(Oc), the fitness of process innovation organization changes with time.

3.2 Model Specification

Process innovation organization is an information processing system, which consist of human and material factors[1]. Assumed that process innovation organization evolution under the circumstance of informationization conforms to the basic principle of Logistic, the evolution path can use sigmoid growth curve of self-organization in ecological system to describe[22]. To simplify the analysis, we set a state variable F, which represents the process innovation organization fitness during the evolution of process innovation organization under the circumstance of informationization. Consequently, the variable F represents the degree that process innovation organization adapts to the surroundings, and changes with the strategy, structure, process and



cultural of organization. The process innovation organization fitness function is $F_i = F(\text{Osti}(r), \text{Osi}(r), \text{Opi}(r), \text{Oci}(r))$, $r(t)$ represents process innovation organization routine, and $F_i(t)$ is a function of time.

$$\frac{dF_i}{dt}$$

Based on this function, $\frac{dF_i}{dt}$ indicates the relative development velocity of the process innovation organization evolution. Then, based on the principle of logistic, we could construct a model to describe the evolution of process innovation organization as following.

$$\frac{dF_i}{dt} = \beta_i \gamma_i F_i \left(\frac{M_i - \sum_{j=1}^n \alpha_{ij} F_j - F_i}{M_i} \right) \quad (1)$$

In this model, F_i represents the fitness of process innovation organization i ; β_i represents the coefficient of information resource development and information technology application influence on the fitness of process innovation organization; γ_i represents natural growth rate of process innovation organization; M_i represents maximum fitness of process innovation organization i under the existing circumstance of informationization; α represents competition (synergistic) coefficient among the process innovation organizations; $\alpha_{ij} = \frac{F_i}{F_j}$ represents

competition (synergistic) effect between process innovation organization i and j , we can judge the relation between process innovation organization i and j is competition or coordination by the sign of α . As a matter of convenience, we only consider the evolution between two process innovation organizations (A and B) under the circumstance of informationization, and the equation set of evolution as follows:

$$\begin{cases} \frac{dF_1}{dt} = \beta_1 \gamma_1 F_1 \left(\frac{M_1 - \alpha_{12} F_2 - F_1}{M_1} \right) \\ \frac{dF_2}{dt} = \beta_2 \gamma_2 F_2 \left(\frac{M_2 - \alpha_{21} F_1 - F_2}{M_2} \right) \end{cases} \quad (2)$$

According to the analysis above, we use Matlab7.1 software to simulate equation (2), and apply software to describe process innovation organizational evolution path curve with different parameters. First of all, in order to investigate the influence of different level of informationization on process innovation organizational fitness, suppose the maximum fitness of process innovation organization is 100, as the coefficient of

information resources development and information technology application affect on the fitness of innovation organization changes, we can draw the fitness curve of process innovation organization applying Matlab7.1. As the diagram 3 shows: as the time changes, with larger coefficient of information resources development and information technology application affect on the fitness of innovation organization, the time for the fitness of innovation organization to reach maximum is shorter, and the velocity of the process innovation organization is faster.

Assume that the existing process innovation organization form is A, and the potential alternative process innovation organization form is B, while the level of information resources development and information technology application is low, the organization prefer efficiency to flexible[23], therefore process innovation organization A (such as functional process innovation organization) is more competitive than process innovation organization B (such as process-oriental process innovation organization), applying Matlab7.1, we can draw the fitness curve of process innovation organization changes with the competition coefficient, as shown in Figure 4. As can be seen from Figure 4, with the improvement of development and utilization of information resources and information technology, competition coefficient of process innovation organization B continually grows from initial lower than A to higher than A. While, fitness curve of process innovation organization A declines from higher than B to lower than B. Therefore, with the improvement of development and utilization of information resources and information technology, process innovation organization A (such as functional process innovation organization) has been gradually replaced by process innovation organization B (such as process-oriental process innovation organization).

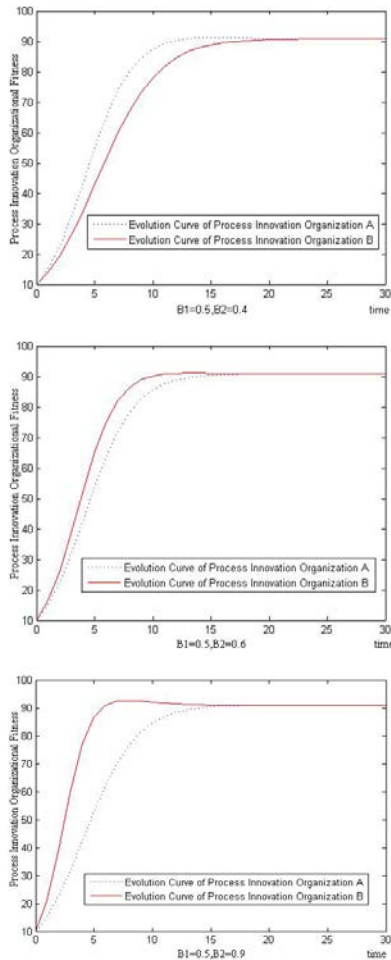


Figure 3: The Influence Of The Level Of Informationization On Process Innovation Organizational Evolution

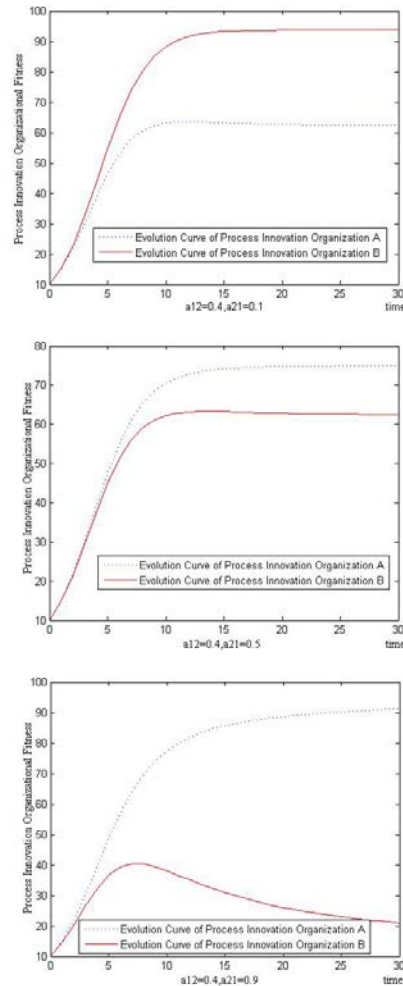


Figure 4: The Influence Of Competition Coefficient On Process Innovation Organizational Evolution

Assume that the existing process innovation organization form is B, and the complementary process innovation organization form is C, applying Matlab7.1, we can draw the fitness curve of process innovation organization changes with the synergy coefficient, as shown in Figure 5. As can be seen from Figure 5, the improvement of development and utilization of information resources and information technology promotes the exchange of market information and technical knowledge, and improves synergy coefficient between process innovation organizations. In the process of organizational evolution, process innovation organization B and process innovation organization C have mutual influence with each other and play the role of catalyst. Eventually the fitness of process innovation organization B and process innovation organization C have been remarkably improved.

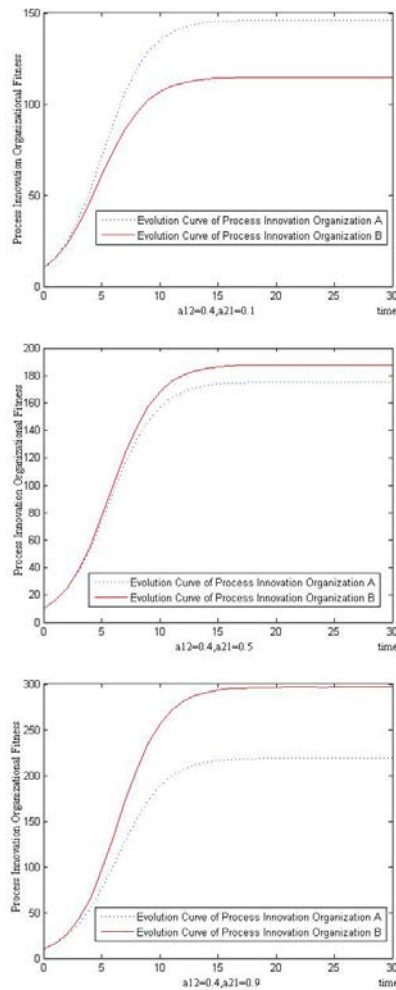


Figure 5: The Influence Of Synergy Coefficient On Process Innovation Organizational Evolution

4. CONCLUSION

Applying the theory of organization and organizational routines, this article has summarized organizational characteristics in manufacturing enterprises under the condition of informationization, which are cooperative strategy, horizontal structure, task-oriented process and adaptive culture. Then this article has put forward that evolution mechanism of process innovation organization is transformation process from traditional organizational routines to process innovation organizational routines through searching and creation, and has constructed the Lotka-Volterra model of process innovation organizational evolution in manufacturing enterprises under the circumstance of informationization, and has used matlab software to simulate the influence of different parameters. Conclusions are as follows: (1) As time goes on,

the larger influence coefficient of information resources development and information technology application on the fitness of innovation organization is, the shorter that time of fitness of innovation organization up to maximum is, and the faster the velocity of process innovation organizational evolution is. (2) With the improvement of development and utilization of information resources and information technology, traditional process innovation organization has been gradually replaced by advanced process innovation organization. (3) The improvement of development and utilization of information resources and information technology promotes the exchange of market information and technical knowledge, and improves synergy coefficient between process innovation organizations. In the process of organizational evolution, process innovation organization parties have mutual influence with each other and play the role of catalyst. Eventually the fitness of process innovation organization parties has been remarkably improved.

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