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Abstract: Based on the analysis of knowledge work's structural characteristics, a relationship model between the knowledge work productivity and the corresponding procedure & standard was established. From the empirical research, this paper pointed that, the process of structuring for knowledge work does not necessarily lead to optimal productivity. The productivity shows a downward trend after the first rise with the structuring of knowledge work. At the same time, for the knowledge work positions with specific knowledge content, their productivity curve showed the first increase after lowering trend with the constant improvement of standardization; The higher the knowledge content of the positions have, the lower degree of standardization of its optimal productivity. This paper analyses the optimal productivity for the corresponding procedure and standard, as well as the innovational behavior potentially exists in the knowledge work with non-procedure and non-standard characteristic. This study puts forward a new perspective of scientific management and people-oriented management for the enterprise as well as provides a new theoretical perspective for the knowledge work productivity study.

Keywords: Knowledge Work, Productivity, structural characteristic, knowledge content

1. INTRODUCTION

More than 100 years ago, the core of Scientific Management created by F. W. Taylor was how to increase the productivity of manual work. The campaign triggered a revolutionary change in traditional management, and came into being modern management theory and practice. Along with the continuous increase of knowledge content in the economic development, the problem of knowledge work productivity has increasingly arisen. The studies on knowledge, knowledge workers and their productivity naturally become a focus of concern for scholars and practitioners [1].

As we can see, for the exploration of productivity, from Taylor explorations of physical work productivity to automation at the machine age, and the current widespread use of information technology, without exception, are the first to grasp the rules of the work, and proposed standards and procedures can be optimized to work. It is believed that the operation can work on the basis of the law on the control and standardization of procedures, is an essential element to improve productivity. However, procedures and standards of knowledge work characteristics are different from Tyler analytical methods for physical work in nature [2]. This is because the characteristics of knowledge work are uncertainty, no standard production time, no clear quality standards, and the task of different workers who have different performance, knowledge work is difficult to observe and measure and so on[3]. These characteristics are associated with different physical work. Characteristics of knowledge work requires us to work on knowledge work of structural analysis is different from physical work.

For knowledge work, many factors influencing knowledge work productivity, such as innovation, customer feelings and so on, were hard to be structured. Inversely, over-structured would blunt workers' ability to innovate, so "structured" was a double edged sword in the management of knowledge work [4]. On the one hand, many contents after "structured" represented the successful experiences of the past, such as the solutions to complex tasks and so forth, which made the work in operation effectively and efficiently either in the past or at

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present[5]. On the other hand, the control process formed by highly "structured", such as appraisal standards, indispensable procedures and so on would hinder a public verification for the belief of work improvement. With the passage of time, it was likely to become the "core rigidities" hindering innovation activities [6]. However, many organizations did not allow individuals spend too much time and resources in new knowledge creation, and the staff also did not have the motive struggling for invalid procedures [7]. In addition, personal knowledge was hard to share if it challenged the work procedures and norms stipulated by organizations, because it has often been considered much difference with the existing mechanism [8].

As for the dual property of "structured" of knowledge work, it was required to distinguish between different factors in knowledge work, to accelerate the work "structured" for those possible; And to seek an innovative model from knowledge work for those working processes (such as innovation) hard "structured", and to realize the standardization of skills and the spreading methods needed in the course of working, or to achieve the standardization of organizational paradigm (shared beliefs, vision, values, etc.), so as to facilitate the coordination of organization and knowledge sharing, converting personal knowledge into public knowledge.

Therefore, it would be an important way to improve productivity how to acquire the rules of structural characteristics of knowledge work, strive to achieve procedural and standardized management of knowledge work; at the same time, how to dig and promote the innovation potential in knowledge work, and promote its sharing.

2. STRUCTURAL ANALYSIS OF THE KNOWLEDGE WORK

The improvement of knowledge work productivity depended on knowledge workers' recognition for their tasks and their choice of ways. The author has found that different workers had their own understanding even the same job position at the same enterprise. After decomposing job contents into a number of main nodes, some workers could continue to sub divide the main nodes into sub nodes, or even continue to breakdown the sub nodes, making the whole structure of the work of three or more layers of tree structure. And some workers divided the work contents into other nodes and layer structure with a different order. So, different understanding of work would bring a different efficiency, quality and innovation. Different understanding of the same job by different knowledge workers just showed the nonstructural characteristics of knowledge work structure itself.

In order to reflect the uncertainty and nonstructural features of knowledge workers' understandings of tasks, this article adopted the hierarchal tree structure to demonstrate.

First of all, we would analyze different k knowledge workers' understandings of their tasks at the same enterprise, the same position. Worker K_1 considered that his tasks should include S_1 sub content by order when finishing them, among which sub content would be represented by a node, namely node S_1. For the tasks of each node, they could be decomposed into several sub nodes further, as tasks of the node S_i could be divided into $C_m^1 + C_m^2 A_2^2 + \ldots + C_m^m A_m^m = M$. Nevertheless, since each worker's knowledge base, working experience, and cognitive abilities was much different, they would have a different decomposition structure even for the same job position. But each worker could decompose his task into the following tree diagram, whose differences lay in the differences of node contents of each level, order and numbers. The numbers of nodes in the figure, as $i_1, i_2, \ldots,$ represented the order of work contents of layer i .

There were at least two reasons why knowledge of the staff of the mission knows the reason why the tree structure was used to describe knowledge workers' understanding of their tasks. First of all, knowledge workers' understanding for the specific job process was progressive objectively, in other words, it was a progressive, deepening process from the overall of tasks to specific operating details, which were reflected in the tree structure. Secondly, levels or progression of knowledge work was also reflected in the following: for a great deal of knowledge work, there were relatively specific procedures and norms on overall (reflected in the first level of

its tree structure), and so were the case even for a lot of advanced knowledge work. And for the following levels, nonstructural characteristics of knowledge work would gradually be revealed. Its sub tasks, as well as procedures, methods of operating details and concrete targets were difficult to determine, totally or partly depending on individual's knowledge, abilities and the experience, and containing innovative factors. They tended to exist in individual workers in the form of tacit knowledge, so the tree structures of different workers were much different at the same job position.

Obviously, the tree structure reflected the overall characteristics of knowledge work structure. At the same time, an effective application of the tree structure would help with converting knowledge workers' tacit knowledge into explicit one.

In order to quantitatively express the degree of difference between the structure tree of the of knowledge work, and analyze its impact on knowledge work performance and potential innovative behavior, this paper uses the concept of entropy. Entropy is a more mature and has been widely used concept, which reflects the uncertainty of things and information is the measure of the degree of system's disorder. If there are multiple different states S, and there is the probability of each state $P = \{p_1, ..., p_n\}$, the entropy of the system can be defined as

$$H_S = -\sum_{i=1}^{n} p_i \log_2 p_i . \qquad (1)$$

In the tree structure described above, the working knowledge of the contents of the i-layer decomposition work, K bits for employee decomposition may be different from each other all the nodes of the m. Each employee of the alternative level job content node is a node of one of m or more.

In the above mentioned tree structure, for the layer *i* in the decomposition of knowledge work, K workers have decomposed the work content, whose separate nodes might be $a_1, a_2, ..., a_m$, m in all. Each worker would select one or more ones among these *m* work content nodes at the level.

Owing to the non-procedural characteristics of the knowledge work, different priorities might exist when two workers were to select the nodes with a same number, same content. Thus, every worker's possible choices would be an orderly arrangement of all nodes, that is, every worker might be facing the following possible choices as: $C_m^1 + C_m^2 A_2^2 + ... + C_m^m A_m^m = M$

Each worker's decomposing way was one of M decomposing ways, where $K = m_1 + m_2 + ... + m_K$

In which $0 \le m_i \le K$, $i = 1, 2, ..., K$. m_i represented repetitive numbers of K workers' selection for decomposing ways respectively. Suppose both workers had selected the first program at the level, then $m_1 = 2$; and suppose all the workers had selected the same decomposing ways at the level, then $m_i = K, m_j = 0, j \ne i$.

In this system, there were K possible states, and the probability of each state p_i was $p_i = m_i / K$, $H'(\Gamma_i^*)$ $\sum_{i=1}^{K} p_i = 1$ so the uncertainty could be demonstrated by the entropy of structure, the entropy value was:

$$H_K(p_1, p_2, ..., p_M) = -\sum_{i=1}^{K} p_i \log p_i = -\sum_{i=1}^{K} \frac{m_i}{K} \log \frac{m_i}{K} \qquad (2)$$

The entropy value reflected the non-procedural, non-normative characteristics of knowledge work through knowledge workers' understanding of their jobs, providing a reference for our seeking the procedure and standardized management model of knowledge work. Meanwhile, it pointed out the direction to probe into the innovative behavior of nonstructural knowledge work.

Firstly, as for the above mentioned entropy value, when $m_{i_0} = K, m_{j(j \ne i_0)} = 0$, the entropy value was minimum, that is, $\min H_K(p_1, p_2, ..., p_M) = 0$. Then, all workers would choose the same ways to decompose the work contents. Sub tasks of knowledge work at the level have acquired higher procedural and normative characteristics. Such

as the basic procedures in the process of software development is “customer needs analysis- system analysis and design - coding - testing” .

When $\frac{m_1}{K}=\frac{m_2}{K}=\ldots=\frac{m_K}{K}=\frac{1}{K}$, or $m_1=m_2=\ldots=m_K=1$, H_K reached its maximum, that is,

$$\max H_K(p_1, p_2, \ldots, p_M) = -\sum_{i=1}^{K}\frac{1}{K}\log\frac{1}{K} = \log K \qquad (3)$$

Then, the decomposition of each worker's job tasks at the level would vary, which brought the differentiation of knowledge workers’ productivity. The differences in each worker's knowledge base, abilities, quality, and enthusiasm, etc., have brought different ways to achieve, as well as the settlement of task goals, so as to lead to the differences of knowledge work in quality, efficiency, innovation, etc.

3. ASSUMPTIONS FOR THE RELATIONSHIP BETWEEN KNOWLEDGE WOK’S STRUCTURAL CHARACTERISTIC AND ITS PRODUCTIVITY

Entropy of knowledge work by structural analysis can be seen, for different types of knowledge work, due to its complexity and the different requirements of innovative tasks, optimal productivity corresponding tree structure is also different, different positions have different work structure entropy. Meanwhile, the same job to work at different times, which corresponds to the optimal level of productivity, is structured differently. Therefore, the productivity function P as a function of tree and time, namely: $\mathcal{P}=\mathcal{P}[\mathrm{H}(\Gamma_i), t]$

Where Γ_i is the tree, is a way to break down knowledge work, $i=1,2,\ldots,l$, l is the total number of species of decomposition methods, $\Gamma=\{\Gamma_1,\Gamma_2,\ldots,\Gamma_l\}$ is the collection of the work tree. This paper puts forward such an assumption: for a particular job knowledge work, in a certain period of time, there should be relatively stable entropy, so that when the structure entropy tends to the value, work productivity to achieve optimal. That is. $\mathcal{P}^{*}=\lim_{H\to h}\mathcal{P}[\mathrm{H}(\Gamma_i), t]$

The increasing structure entropy implies procedures and standardization of knowledge work are constantly reduced. Therefore, in order to reflect the change trend of knowledge work productivity with the increasing structural degree, this paper use reciprocal structure entropy as the horizontal axis, in order to ensure the direction of change in value to be consistent with structural degree axis , the relationship between the degree of structure (structure entropy), so let $H'(\Gamma_i^{*})=1/H(\Gamma_i^{*})$. The relationship between structure entropy and its productivity showed in Figure 1.

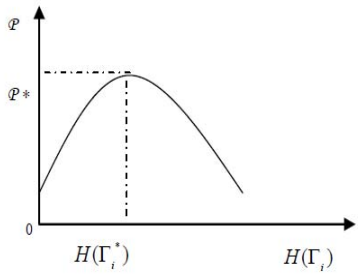

Figure 1. The structural entropy—productivity model of knowledge work

In the above model, the curve can be divided into two parts to be analyzed separately. First, in the rising part of the curve, with the improvement of structural degree, knowledge work productivity has a corresponding increase. This law can be applied to the organization's management practices. For those work contents which are easy to standardize, we should apply scientific management for them. It is more beneficial to improve their productivity. While with the continued improvement of structural degree, the productivity will be reduced after a certain point. This change law of productivity is just reflect the characteristics of knowledge work, namely, too rigid way of work method and working system would stifle the creative thinking of knowledge workers. From the psychological preferences, the knowledge workers do not want to be subject to rigid forms of work, such as a fixed time and fixed workplace, they prefer to work

independently. The fixed working system is detrimental to their creative activity. This part of curve corresponds to knowledge works which are difficult to standardize, so we need apply other methods different from scientific management.

As we see, under the analytical framework of structural entropy, we discussed the knowledge work productivity, finding the optimal productivity of the corresponding procedure& standard and the innovational behavior potentially exists in the knowledge work. As for the knowledge work, procedures and standardization does not necessarily lead to optimal performance. Too high or too low procedures and standardization will affect the productivity of knowledge work. Combining with the theoretical analysis, this paper puts forward the corresponding hypothesis:

H1: with the improvement of procedures and standardization of knowledge work, its productivity shows a downward trend after the first rise.

H2: Different levels of knowledge content [9] for knowledge work, corresponding to the different productivity curve. The higher the knowledge content of the position, the optimal productivity corresponding to the lower degree of procedures and standardization; the lower the knowledge content of the position, the optimal productivity corresponding to the higher degree of procedures and standardization.

The corresponding empirical research will be given in the following context.

4. QUESTIONNAIRE DESIGN AND SAMPLE SELECTION

As noted above, for knowledge work, standardization and procedure does not necessarily lead to optimal productivity. Too high or too low standardization & procedure will affect the productivity of knowledge work.

First, procedures and standards as a fundamental attribute for the work, they form a basic structure of the work. At present, the research of work procedures& standards focused on a variety of specific job analysis, such as nursing, administration, project management, and service work. These studies mainly described the specific work procedures for improving the efficiency and quality of these kinds of work. But the research on the measurement of procedures and standards indicators is still limited.

Zhang Guangming pointed out that, the procedures and standards for work should be include the work content , operation methods, the corresponding rules interface between the front and rear, as well as a feedback mechanism [10]. Zhou Peng pointed out that, the work standardization usually includes two aspects, that is the standardization in the work processes and results (i.e. output). Through developing standards for the work process, we can standardize individual work and achieve coordination between related works. At the same time, we can improve the work quality and efficiency through developing the standards for different results of the work [11]. Meanwhile, the standardization of knowledge work also includes the standardization for skills and beliefs of staff. Henry Mintzberg noted that, some of the work process cannot be fully standardized [12]; you will need standardization for work skills required by the knowledge. At the same time, coordination and sharing of knowledge is a critical factor for innovation, which requires each employee has the same belief to realize the standardization for organizational paradigm (belief, vision and values, etc.) [13].

Based on existing literature and related interviews research the author conducted preliminarily, this article will describe the indicators of procedures and standards as follows. The work procedures refer to all aspects of the work process or workflow priorities. The procedural attributes include the clarity of work priorities, the degree of change in the work procedure, and the extent of the work results can be timely feedback. The work standard refers to the guidelines developed to measure the content, methods, procedures, and quality of the work. The standard attributes include the clarity to the work process standards contents, the results measurement of the work, the extent of the knowledge and skills needed to complete the work, node content defined in the extent, as well as the clarity to the organizational values.

Secondly, the index measuring research productivity of knowledge work, the current academic perspective emphasizes the importance of quantifying the needs and knowledge worker productivity metrics. In the previous literature on knowledge worker productivity measurement study, researchers used a lot of productivity dimensions [14]. However, no single method can cover all dimensions. There are also some dimensions which are viewed as important, but were not well applied in the actual measurement. [15]Knowledge worker productivity dimensions usually include quantity, quality, cost, innovation, efficiency, customer satisfaction, responsibility, employees' perception for productivity etc. [16].

For knowledge work, its higher frequency dimension of efficiency, quality and innovation. At the same time, customer satisfaction is usually viewed as an invisible index [17]. Collaboration is an important indicator to measure the productivity of knowledge work [18]. Therefore, measuring the productivity of knowledge work consists of five indicators that are efficiency, quality, innovation, customer satisfaction and collaboration.

In order to obtain empirical research data, the authors conducted a questionnaire survey. The survey involved in financial, management consulting, manufacturing, insurance, information, commerce and other industries. The samples are composed by professional managers, *R&D* personnel, sales personnel, functional managers, management consultants and technical service personnel and production Operator, who are mainly come from an institute of adult education, three IT companies and a business college. The questionnaires were distributed 400 copies, 310 questionnaires were valid eventually.

5. CONFIRMATORY FACTOR ANALYSIS

First of all, the part of the main characteristics of this article based on the attributes of knowledge work, through questionnaires, using structural equation modeling (SEM) method, the knowledge of two-dimensional work of structural properties (i.e., procedures and standardized feature dimensions) to verify the reasonableness analysis of factors. In order to verify the reasonableness of the two-dimensional properties of the model, this paper will compete with the other two: single-factor model and three-factor model. Goodness of fit index characteristic structure of the model is shown in Table 1.

Table 1. Fitting indexes of structural model of the knowledge work

Model to be estimated	Chi2	df	Chi2/df	RMSEA	GFI	AGFI	NFI	CFI	NNFI
Single-factor model	400.91	65	6.17	0.183	.71	0.60	0.72	0.75	0.70
Three-factor model	220.18	62	3.55	0.129	0.82	0.74	0.83	0.86	0.83
Two-factor model	222.36	65	3.42	0.075	0.87	0.82	0.87	0.89	0.83

As can be seen from the table, the three models fit index gradually improving, but in comparison, it is clear that two-factor model is the most ideal model. Its Chi2/df is the minimum; RMSEA (0.075) is also in an acceptable range.

Second, similar to the above structure for knowledge work rationality validation analysis, the main part of the five dimensions of knowledge work productivity indicators rationality validate proof structure with five dimensions reaction productivity of knowledge work is reasonable. PR1-PR5 which in turn means: efficiency, quality, customer satisfaction, innovation, and collaboration. There is still using structural equation modeling techniques for confirmatory factor analysis. In the initial five-dimensional productivity assumptions in the model, the goodness of fit index RMSEA = 0.110> 0.008, described the extent of the fitted model is not ideal. Therefore, the model needs further amendments. Because of the observed variables in latent variable PR5 low load (collaboration index) on the error variance and higher load, so first consider the removal of PR5, to modify the model. After removing factors PR5, corrected the hypothetical model. Each goodness of fit indices compare

d between two models as shown in Table 2.

Table 2. Fitting indexes of knowledge work productivity

Model	Chi2	df	Chi2/df	RMSEA	GFI	AGFI	NFI	CFI	NNFI
The initial model	14.30	5	2.86	0.110	0.96	0.89	0.95	0.97	0.94
Modified model	4.26	2	2.13	0.086	0.99	0.93	0.98	0.99	0.96

By comparing the two models, we can see that modified model is better in the main fitting indexes. Therefore, this article will use the four indicators of productivity (that is efficiency, quality, customer satisfaction and innovation) for the following analysis.

6. HYPOTHESIS TESTING

In this paper, we use interactive chart of SPSS18.0 as the analysis tool. At first, all samples (310) were smooth fit; we get respectively the procedural - productivity curve and standard - productivity curve. Secondly, sub-samples of 50 high knowledge content and 50 low knowledge content were respectively selected; we got the four relationship curves between procedure& standard and corresponding productivity with different knowledge contents.

6.1 The relationship curves between procedure& standard and its productivity with all samples

All samples of knowledge work procedure - productivity curve and standardization -productivity curve as shown in figure 2.

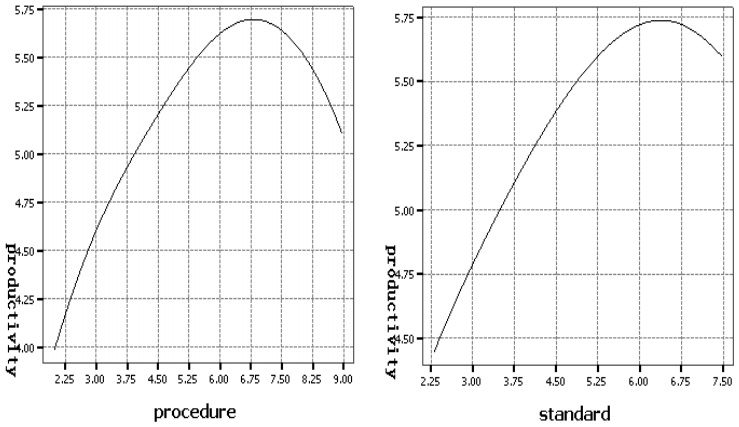

Figure 2. The Relationship Curve of procedure& standard and productivity for the total sample

Through graphic analysis can be seen, with improvement of its procedure and standardization for the knowledge work, its productivity increased first and then decreased. In addition, by comparing the degree of standard and procedure, we found that the optimal level of productivity corresponding procedures degree slightly higher than degree of standardization. This shows that, the higher degree of standardization is more likely to cause low productivity of knowledge work.

6.2 The relationship curves between procedure& standard and productivity with high-level knowledge content sample

The relationship curves between procedure& standard and productivity with high-level knowledge content sample are shown in figure 3.

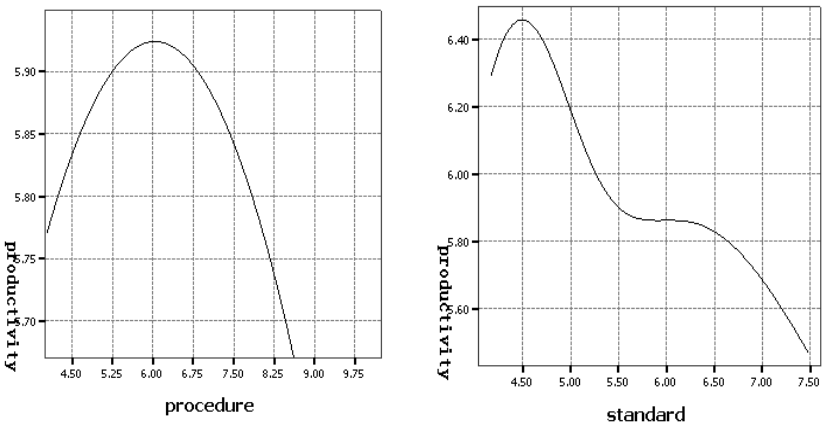

Figure 3. The Relationship Curve of procedure& standard and productivity for high-knowledge contents sample

As can be seen, for the high knowledge content of knowledge work is concerned, the optimal productivity of knowledge work is corresponding to the program and standardization of low degree. That is, the higher the content of knowledge work, its optimal productivity of the corresponding program and standardization degree is lower.

6.3 The relationship curves between procedure& standard and corresponding productivity with low-level knowledge content sample

The relationship curves between procedure& standard and corresponding productivity with low-level knowledge content sample are shown in figure4.

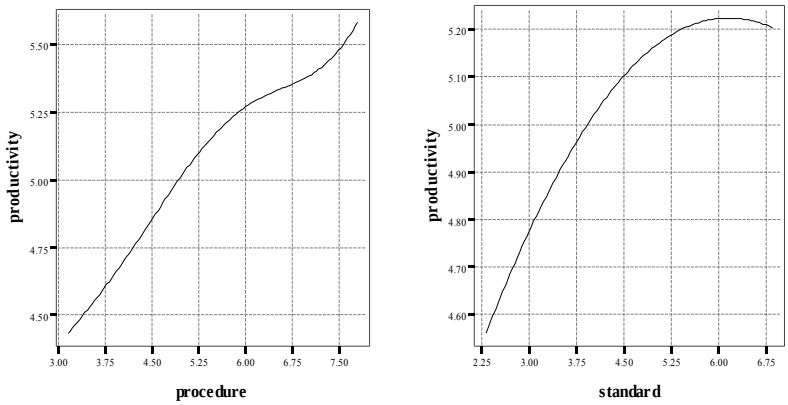

Figure 4. The Relationship Curve of procedure& standard and productivity for low-knowledge contents sample

As can be seen, for the low content of knowledge work, the rising part of the curve basically is still in the curve model, illustrate the procedure, the optimal productivity requires a higher degree of standardization. That is, the lower the knowledge content of jobs, the optimal productivity of the corresponding procedures, standardization degree is higher.

Therefore, through the empirical research, this part separately verifies the two hypotheses proposed: knowledge work productivity with its procedure standardization and improvement, increased first and then decreased with the. The content of knowledge of the different positions of the knowledge work productivity, structured relationship curves corresponding to different. Among them, the knowledge content more low post, programming, the optimal productivity of the corresponding specification degree is high; the higher the content of post knowledge, its optimal productivity of the corresponding

procedures, standardization degree is low.

7. CONCLUSIONS

For China's knowledge-based enterprises, they have not gone through Taylor's scientific management phase, and now we are facing the challenges of the knowledge work productivity. Physical worker productivity has been satisfactorily resolved, which is the necessary prerequisite to the knowledge worker productivity discussed by Drucker. Although companies usually viewed worker's innovation, customer's emotion which is difficult to structure as their core competitiveness, while in many enterprises, a large lot of work contents which should be structured are still in the lack of scientific management stage. For these easily structured work contents, lack of standardized management has seriously affected the work performance. In management practice, managers should implement appropriate management ways based on different characteristics of the work contents and promote continuous improvement in knowledge work productivity.

Starting from the nonstructural characteristics of knowledge work, this paper analyzed the hierarchical structure of knowledge work and established a tree-structure model of knowledge work based on the characteristic. Through this model, this paper analyzes the uncertain understanding to the task of knowledge workers, as well as knowledge work's non-procedural and non-standard characteristic. Meanwhile, this paper introduces the concept of entropy, for the quantitative expression of the degree of non-procedure and non-standardization. This paper puts forward a new perspective of procedure and standard for raising the knowledge work productivity.

Secondly, based on the analysis of different positional knowledge content, this paper established a relationship model between the knowledge work productivity and the corresponding procedure& standard. As for the knowledge work, procedures and standardization does not necessarily lead to optimal performance. Too high or too low procedures and standardization will affect the productivity of knowledge work. we pointed that, the methods of standardization management should vary for different positions, Acquiring the structural characteristics of the work and striving to achieve the standardized management, this model provide a reference for the establishment of scientific management. At the same time, the model also pointed out the direction for mining the innovative behavior embodied in the knowledge work.

At last, from the empirical research, we found that, for the knowledge work positions with specific knowledge content, their productivity curve showed the first increase after lowering trend with the constant improvement of standardization; The higher the knowledge content of the positions have, the lower degree of standardization of its optimal productivity.

In short, the structural rules of knowledge work and its effective application on productivity is still no systematically study. This study makes an attempt at the exploration of the theory and practice for knowledge work productivity.

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