THE IMPACT OF BIG DATA APPLICATIONS ON KNOWLEDGE CREATION IN R&D TEAM, KIBS ENTERPRISES

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Abstract

It is an indisputable fact that the era of big data is coming. It has practical guiding significance to study the impact of big data applications on the field of management. In this paper a questionnaire survey was carried out among software enterprises in twelve provinces of China, and statistical analysis methods were used to empirically study the impact of big data applications on knowledge creation in R&D team, KBIS enterprises (Knowledge-intensive business services enterprises). The study found that big data applications have a significant positive impact on knowledge creation in R&D teams, KIBS enterprises. In this paper the related factors about the impact of big data applications on knowledge creation in enterprises have been obtained and the study also enriches the related theories of big data research in the field of management.

Keywords: Big Data, KIBS Enterprises, R&D Team, Knowledge Creation

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Introduction

In the era of big data, data have become a vital non-material strategic resource in addition to knowledge. Enterprises can increase their knowledge stock so as to improve their competitive advantage by getting related valuable knowledge from big data. Tao & Shang (2018) proposed that big data is not only a technical issue, but also a management issue.

Knowledge-intensive business services (KIBS) is a new type of service industries which use network and information technology as their main background, intellectual capital as their main inputs and high added values, high profitability, professionalism and knowledge as their outputs. In the 1980s, service industries in western developed countries gradually took the place of manufacturing and became the driving force of economic development. When Wood, Bryson & Keeble (1993) researched the development of the British service industries in this period in 1993, he first proposed using the term knowledge-intensive to describe the main features of KIBS enterprises. Currently, the development level of KIBS has become an important symbol for a country to measure the level of its social economy and modernization. As knowledge-based enterprises, KIBS enterprises have a high dependence on the knowledge, and knowledge is the foundation of KIBS enterprises. R&D Team is the core unit to develop knowledge creation activities and creates enterprise value in KIBS enterprises. Therefore, it has certain practical significance and urgency to study the impact of big data applications on knowledge creation in R&D team, KIBS enterprises. But according to the existing literature, there are only a small number of researches on the impact of big data in the management field, most of them are qualitative researches, and empirical studies are too rare.

Research Objective

According to the above research background and research issues, this paper attempted to use empirical research methods to research the emerging IT technology — the impact of big data applications on knowledge creation in R&D team. This paper is expected to achieve the following objectives:

(1) To build a relational model between big data applications and knowledge creation in R&D team.

(2) To evaluate the impact of big data applications on knowledge creation in R&D team by using empirical research method.

(3) To enrich knowledge creation theory, provide theoretical basis for studying the impact of emerging IT technology on knowledge creation, and provide new research ideas for knowledge creation research.

(4) Through the conclusion of this study, it provides practical advice for knowledge creation in enterprises, and guides practical activities of knowledge creation in enterprises in a better way.

Literature Review

1. Theory of Knowledge Creation

Undoubtedly SECI (Socialization, Externalization, Combination and Internalization) model of knowledge creation proposed by Nonaka &

Takeuchi (1995) clearly explains the process of knowledge creation and it has also become the foundation of the knowledge creation in the field of management. In SECI model four spiral mutual conversions between explicit knowledge and tacit knowledge are put forward, they are Socialization, Externalization, Combination and Internalization. In 1998 Nonaka & Konno proposed the concept of "Ba" under the background of knowledge creation in SECI model. "Ba" is a shared situation and it is the background for promoting knowledge sharing, knowledge creation and knowledge application. "Ba" is very crucial that it provides energy, quality and place for personal knowledge and the spiral of knowledge. The research on the impact of knowledge creation in this paper is based on the SECI model knowledge creation.

2. Research on Knowledge Creation in R&D Team, KIBS Enterprises

Strambach (2001) believes that knowledge creation in KIBS enterprises also has four processes of knowledge creation proposed by Nonaka and Takeuchi. Zhang & Du (2007) proposed that the service process of KIBS is the knowledge creation process in enterprises. And the task of this service process is often assigned to R&D team to complete.

3. Research on the Role of Information Technology in Knowledge Creation

Davenport & Prusak (1998) believes that information technology is an important factor in the process of knowledge creation. Lee & Choi (2003) also think that various forms of information technology can help individuals and organizations collect, acquire, and exchange knowledge, thus promoting them to create new knowledge. Taking virtual technology as an object, Vaccaro, Veloso & Brusoni (2009) researched the process of knowledge creation in organizations based on the SECI model and found that information technology played an auxiliary role in the process of Socialization. In the process of Externalization, no positive contributions brought by information technology have been found. In the process of Combination, information technology plays a supporting role. And in the process of Internalization, part of information technology can promote the Internalization of individual knowledge, and meanwhile promote the standardization of organization management and knowledge transfer.

4. Research on Big Data Application Dimension

4.1 The Concept of Big Data Applications

Cooper & Zmud (1990) proposed the concept of IT application from the perspective of technological innovation. That is, IT application is an information technology encouraged by enterprises to use and play its role under the framework of information technology. Kuang & Wang (1999) proposed that IT application refers to the application of information technology in enterprises. Wang (2015) defines cloud computing applications as a new information technology that uses cloud computing to promote the competitive advantage of enterprises through the application of its technical characteristics. As big data is an emerging technology, this paper defines big data applications from the

perspective of technological innovation. That is, big data applications refer to the new information technology, which the emerging technology big data is used by enterprises to create value through the diffusion of its technical characteristics so as to improve and maintain the core competitiveness of enterprises.

4.2 Big Data Applications Dimension

Scholars have also put forward many viewpoints about the technical characteristics of big data. Marr (2017) proposed that if enterprises outsource related big data business to professional big data service providers, the investment and human resources cost of IT infrastructure can be reduced. And this is also the trend for enterprises to implement big data applications. Hu, Zhang & Li (2013) analyzed the characteristics of big data applications such as technology outsourcing, technology intelligence (including on-line analysis and data mining) and technology visualization through business cases in their literature reviews of big data applications. Ren et al. (2014) summarized visualization analysis of big data and proposed that the technical characteristic of automatic intelligent analysis, dynamic analysis and strong visualization of big data is the cornerstone to promote the development of big data applications. Therefore, integrating the above viewpoints, big data applications can be summarized into 3 dimensions: technology outsourcing, technical intelligence and strong visualization.

Theoretical Model and Hypothesis

1. Theoretical Hypothesis

As a result of big data applications, many manual work of knowledge creation can be done by machines. Therefore, it is proposed that big data applications have a positive impact on the knowledge creation in R&D team, the following theoretical hypothesis is put forward:

H: Big data applications have a significant positive impact on the knowledge creation in R&D team.

The relationship between each dimension is analyzed and the theoretical hypothesis is refined as below:

(1) The relationship between big data applications and Knowledge Socialization in R&D team.

Before the development of software, R&D team members have to learn the users' business process very well and understand the users' business procedures and business demand by observing, communication, and even post practice. This is the conversion process from users' tacit knowledge into the team members' tacit knowledge, and it is also the process of Knowledge Socialization in R&D team. During this process, R&D team can use the users' oriented information from big data analysis to recommend related software functions to users, and then affect the users' demand. Therefore, big data applications have a positive impact on the Knowledge Socialization in R&D team, thus the following hypothesis is put forward:

H1a: Technology outsourcing has a significant positive impact on the Knowledge Socialization in R&D team.

H1b: Technical intelligence has a significant positive impact on the Knowledge Socialization in R&D team.

H1c: Strong visualization has a significant positive impact on the Knowledge Socialization in R&D team.

(2) The relationship between big data applications and the Knowledge Externalization in R&D team

At the phase of requirements analysis of software development, the investigators' records, oral statements and so on have to be sorted out and translated into documents that conform to the professional standards. Then knowledge obtained by investigation will be encoded. And innovative software architecture, software architecture and function modules and so on will be designed. This is the process of conversion from tacit knowledge into explicit knowledge, and it is also a highly innovative process. With big data applications, requirements analysis and design can be excavated by big data technology through the content of reusable analysis design, such as users' orientations, new technologies and new ideas. Finally, the best scheme can be selected automatically and intelligently. Therefore, big data applications have a positive impact on Knowledge Externalization in R&D team, thus the following hypothesis is put forward:

H2a: Technology outsourcing has a significant positive impact on the Knowledge Externalization in R&D team.

H2b: Technical Intelligence has a significant positive impact on the Knowledge Externalization in R&D team.

H2c: Strong visualization has a significant positive impact on the Knowledge Externalization in R&D team.

(3) The relationship between big data applications and the Knowledge Combination in R&D team

After the research and development in R&D team entering into the code writing and software testing phase, the explicit knowledge of existing documents and design materials will be used, and the acquired knowledge will be transformed into the computer acceptable code, and then the coding will be integrated into the software function module. It is a process from explicit knowledge to explicit knowledge, and it is the process of Knowledge Combination through computer coding and network. With big data applications, the programming and testing of program code can be automatically completed by the big data platform, many mature and stable codes will be excavated and the best scheme can be selected intelligently. Finally, the test results and defects of the program are predicted, so that programmers can solve the problems of software efficiently. Therefore, it is proposed that big data applications have a positive impact on the Knowledge Combination in R&D team, the following theoretical hypothesis is put forward:

H3a: Technology outsourcing has a significant positive impact on the Knowledge Combination in R&D team.

H3b: Technical Intelligence has a significant

positive impact on the Knowledge Combination in R&D team.

H3c: Strong visualization has a significant positive impact on the Knowledge Combination in R&D team.

(4) The relationship between big data applications and the Knowledge Internalization in R&D team

The last phase is product output phase. Programmers will use the written functional modules to quickly integrate into a complete software system, and complete the overall test. After the test is passed, the software prototype will be published and tried out by users, then modified according to users' feedback. This is the process that programmers can convert explicit knowledge into tacit knowledge by their own practice, and it is the process of programmers' Knowledge Internalization. In this process big data applications can dynamically track and test the whole software system and predict fault points or software defects accurately, so that programmers can find and solve problems quickly. Therefore, it is proposed that big data applications have a positive impact on the Knowledge Internalization in R&D team, the following theoretical hypothesis is put forward:

H4a: Technology Outsourcing has a significant positive impact on the Knowledge Internalization in R&D team.

H4b: Technical Intelligence has a significant positive impact on the Knowledge Internalization in R&D team.

H4c: Strong Visualization has a significant positive impact on the Knowledge Internalization in R&D team.

2. The Construction of the Theoretical Model

Based on the above theoretical hypotheses, a theoretical model is proposed for the study in this paper, as shown in Figure 1:

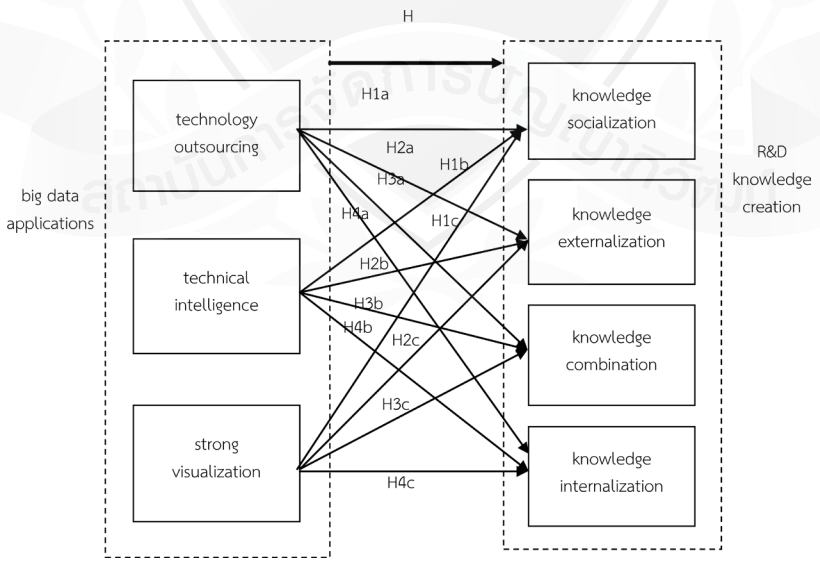

Figure 1 The model diagram of the impact of big data applications on knowledge creation in R&D team

Research Methods

1. Measurement Scales

The mature scales in China and other countries were used for reference to the measurement scales of each dimension in this paper. According to the research hypothesis, the independent variable is the 3 scales contained in big data applications which are technology outsourcing, technical intelligence, and strong visualization. The dependent variable is knowledge creation, which includes 4 scales: Knowledge Socialization, Knowledge Externalization, Knowledge Combination and Knowledge Internalization. The viewpoints of the investigation objects are measured by the five-level Likert scale.

2. Questionnaire Design

In this paper, the questionnaire was designed by four steps: literature review, pre-test interview, trial investigation, and small sample pre-test. After the preliminary design of the questionnaire, the questionnaires were first distributed in a small scope, and 52 small sample data were obtained. Cronbach's coefficient test, exploratory factor analysis and confirmatory factor analysis were applied to the small sample data. And the original questionnaire was adjusted and revised according to the pre-test results. In the end, the questionnaires were widely distributed to obtain large sample data.

3. Data Distribution and Collection

This paper takes Chinese software enterprises as research objects. In order to get data from different regions as many as possible, Questionnaire Star developed by Tencent was used to make electronic questionnaires. And WeChat was used to distribute the questionnaires in the way of snowball and take back the questionnaires. The questionnaires were distributed in 12 provinces, municipalities and autonomous regions in china where the economy is more developed, and the small sample data were completely covered. At last, 675 questionnaires were taken back and 86 invalid questionnaires among them were removed. The final valid questionnaires were 589. And the valid rate of the questionnaires was 87.3%.

4. Analysis Tools and Analysis Methods

This study applied SPSS19.0 and AMOS23 statistical analysis software to conduct statistical analysis and hypothesis testing on the collected data. The statistical analysis methods used in this study are: reliability validity test, factor analysis, correlation analysis and regression analysis.

Testing and Analysis

1. Reliability Testing

(1) Cronbach's α Coefficient and CITC Testing

SPSS19 was used to test CITC and the α value of each item of big data applications in large sample data. From the test results, the α value of all the items is more than 0.8, and CITC of all the items is more than 0.4, it shows that the overall reliability is very high and the reliability is very strong. Therefore, the reliability of sample data of big data applications meets the research requirements.

(2) Exploratory Factor Analysis

The test result of big data applications is: KMO = 0.881, Bartlett spherical value = 1809.479, statistics significance level Sig = 0.000. The test result of knowledge creation is: KMO = 0.924, Bartlett spherical value = 3861.772, statistics significance level Sig = 0.000. Therefore, this research scale is suitable for factor analysis.

The result of the total variance test in factor analysis is: 3 factors are extracted from big data applications, and the total variance ratio of three common factors is 70.480%. 4 common factors are extracted from knowledge creation, and the total variance accumulation is 69.16%. The test results coincide with the previous setting dimensions of big data applications and knowledge creation.

2. Validity Analysis

The validity is divided into content validity and structure validity. (1) Content Validity Analysis. The existing mature scales were used directly or indirectly in the measurement items of this paper which were sorted out after listening to the opinions of the experts group and visiting enterprises. Therefore, the maturity of the measurement problem and the stability of the factor structure are very high. (2) Structural Validity Analysis. The scales were adjusted and corrected by the testing of small sample and the result of factor analysis, and the expected effect was achieved. Therefore, the scales and questionnaires used in this study have better structural validity.

3. Analysis and Testing of ICC and r_{wg}

Since team issues are researched by personal data in this paper, it is necessary to verify the structure validity of the integration of individual level data into the team level data. There are two main methods of verification:

One is index analysis method. After single factor variance test is used to get MSB and MSW, then ICC (1) and ICC (2) will be calculated. And these two indexes can be used to judge whether the personal level data is suitable for integration into team level data. The other one is r_{wg} analysis method. The consistency coefficient within the team is tested, that is, to measure a variable through multiple items to test whether the responses of the team members are consistent.

Finally, the test results of all dimensions are: ICC (1) are all larger than 0.05, ICC (2) are all larger than 0.5, r_{wg} mean values are all larger than standard values 0.7. Therefore, the sample data have good consistency, and can be integrated into team level data for further analysis.

4. Correlation Analysis

Before the regression analysis, it is necessary to analyze the independent variables so that the multicollinearity problem can be avoided. Therefore, this paper will verify the correlation of each dimension of these two variables: big data applications and the knowledge creation in R&D team. The results showed that the Pearson correlation coefficient between big data applications and the knowledge creation in R&D team is 0.812, indicating that there is a highly positive correlation between them. The correlation testing results from each dimension

also showed that there is a significant positive correlation between big data applications and knowledge creation in R&D team.

5. Hypothesis Testing

The hypothesis testing of this study is based on the principal component regression method. That is, before the regression testing is done, the score of each factor (Fi) and its comprehensive score (F) are calculated. Fi and F are used for regression analysis. The calculation formula is as follows:

(1) Formula for factor scores

$F_i = c_1x_1 + c_2x_2 + ... + c_ix_i$

Note: c_i is the score coefficient of the principal component for each variable, x_i is variable, i = 1,2,3... n.

(2) Formula for comprehensive scores

$Z_i = w_1F_1 + w_2F_2 + ... + w_iF_i$

Note: w_i is variance contribution rate of corresponding factor, F_i is factor score, i = 1,2,3... n.

According to the above formula, the comprehensive score of big data applications D is obtained, so is the comprehensive score of knowledge creation in R&D team Z. And the factor scores of three dimensions of big data applications are respectively D1 (technology outsourcing), D2 (technical intelligence) and D3 (strong visualization), the factor scores of the four dimensions of R&D knowledge creation are Z1 (Knowledge Socialization) 、Z2 (Knowledge Externalization) 、Z3 (Knowledge Combination) 、Z4 (Knowledge Internalization) respectively.

(1) Hypothesis Testing of Big Data Applications and Knowledge creation in R&D team

A linear regression analysis was done by using the comprehensive score of big data applications and knowledge creation in R&D team. And the result is as follows:

Table 1 A linear regression analysis of big data applications and knowledge creation in R&D team

Model		Not Standard regression coefficient	Standard error	Standard regression coefficient	t	R^2	F	P
1	constant	2.037	0.211		9.636	0.186	59.167	0.000
	Big data application	0.432	0.056	0.431	7.692			

From the results of Table 1, the coefficient of determination R^2 = 0.186, indicating that big data applications explain the changes in the knowledge creation of the R&D team by 18.6%. The significant level of P < 0.01, shows that the R-squared is quite good. Value F = 59.167, the value of the standard regression coefficient is 0.431, and the significance level of P < 0.05, shows that the regression effect is remarkable. Therefore, it is believed that big data applications have a significant positive impact on the knowledge creation in R&D team, and the H

hypothesis is verified.

(2) Hypothesis Testing of Big Data Applications and Knowledge creation in R&D team

Multiple linear regression analysis was carried out on the factor scores of three dimensions of big data applications and four dimensions of knowledge creation in R&D team, and the result is as follows:

Table 2 Multiple Linear Regression Analysis of Big Data Applications and Knowledge Socialization in R&D team

Model		Not Standard regression coefficient	Standard error	Standard regression coefficient	t	P	VIF	R2	DW
1	constant	0.844	0.286		2.954	0.003		0.283	2.021
	D1	0.270	0.067	0.241	4.043	0.000	1.273		
	D2	0.281	0.059	0.280	4.763	0.000	1.238		
	D3	0.196	0.067	0.172	2.909	0.004	1.259		
2	constant	0.881	0.213		4.140	0.000		0.453	1.903
	D1	0.246	0.050	0.398	4.949	0.000	1.238		
	D2	0.340	0.044	0.216	7.760	0.000	1.259		
	D3	0.209	0.050	0.258	4.176	0.000	1.273		
3	constant	0.255	0.202		1.259	0.209		0.547	2.075
	D1	0.390	0.047	0.391	8.245	0.000	1.273		
	D2	0.264	0.042	0.295	6.324	0.000	1.238		
	D3	0.281	0.048	0.278	5.897	0.000	1.259		
4	constant	1.213	0.249		4.869	0.000	1.273	0.304	1.938
	D1	0.266	0.058	0.268	4.565	0.000	1.238		
	D2	0.201	0.051	0.226	3.912	0.000	1.259		
	D3	0.229	0.059	0.227	3.893	0.000	1.273		

From Table 2, the Durbin-Watson is between 1.5 and 2.5, indicating the independence between the samples. VIF is less than 5, that is the multicollinearity among D1, D2, D3 in the 3 models did not exist, R^2 were 0.283, 0.453, 0.547, 0.304, Z1 can be explained by variation of 28.3%, 45.3%, 54.7%, 30.4%, and D1, D2, D3 have significant positive impact on Z1, Z2, Z3, Z4 (β are all more than 0.2, P are all less than 0.05). It is obvious that the results of this study are significant and supported the hypothesis.

Analysis and Discussion of Results

From the results of the test, all the research hypotheses were tested and met the expectations of the research in this paper, but they were not completely consistent with the viewpoints of Vaccaro, Veloso & Brusoni (2009). From the overall test between big data applications and knowledge creation in R&D team, the R^2 is 0.186, and the R^2 of knowledge combination is 0.547, they are both larger than any other dimension. This shows that big data applications have the highest contribution to Knowledge Combination.

The cause of the above results is as follows: Because of the high intelligence in the production process of knowledge products, many tasks of Knowledge Externalization such as system design originally completed by research and development personnel are now completed by computer systems. And the process of tacit knowledge converting into explicit knowledge is weakened. It can be seen that big data applications have a powerful auxiliary impact on Knowledge Externalization. At the same time, under big data applications, the process of explicit knowledge converting into explicit knowledge occupies an extremely important position, that is, the process of Knowledge Combination is strengthened.

Conclusion and Prospect

(1) Research Conclusion

This paper concludes that big data applications have a significant positive impact on knowledge creation in R&D team, KIBS enterprises. And big data applications have a significant positive impact on each knowledge conversion process in R&D team in KIBS enterprises. Big data applications especially have more profound impact on the process of Knowledge Combination.

(2) Practical Enlightenments of the Conclusion

The IT characteristic of big data creation and innovation is the core driving force to promote big data applications.

The IT characteristic of big data creation and innovation (including the innovation of application mode) is an important symbol of big data technology which is different from other IT technologies, and is also the driving force of the enterprises to implement big data applications. The 3 technical characteristics of big data applications summarized in this paper can help enterprises get rid of the bondage of IT ability, lay down the burden of IT resources, save the cost of enterprises, and wholeheartedly

develop the core business and innovation of enterprises. At the same time, the process of knowledge creation activities in enterprises is simplified, the efficiency and quality of knowledge creation are greatly improved, the demand for human resources is reduced and the cost of enterprises can be saved. Therefore, the IT characteristics of big data applications are the fundamental reason and driving force to promote big data applications.

Big data applications can improve the efficiency of enterprises and strengthen their own competitive advantages.

The empirical results in this paper show that big data applications have a significant positive impact on knowledge creation in KIBS enterprises, which are in line with the research expectation in this paper. In the process of knowledge creation under big data applications, the original knowledge creation behaviors or activities dependent on human are no longer dependent on human beings, they are completed by machines. In addition, big data applications can be completed in real time, and the presentation of their creation results is also real time. This makes the efficiency of enterprises increase greatly. At the same time, the demand for human resources can be reduced and the competitiveness of enterprises will be enhanced.

(3) Research Prospect

The future researches will not be limited to KIBS enterprises and R&D team, and the scope of the researches will be expanded to verify whether the conclusion is still valid. Meanwhile the intermediary or control effect of other variables will be considered, such as whether different regional enterprises will have impact on the relationship between big data applications and knowledge creation.

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