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Research and Development of R & D Team in Chinese Enterprises

—Taking Liaoning Province as an Example

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Abstract—In order to find out the relationship between R&D team building and the development of enterprises, this study adopts the method of empirical investigation to track the status quo of R&D team building of four typical enterprises in Liaoning Province of China, and finds that the enterprises that attach importance to R&D have developed rapidly, otherwise the contrary. The main problems of R&D team construction in enterprises are lack of high-end leading talents, and some R&D teams are unreasonable. The government lacks a strong talent mobility policy to support enterprises to absorb high-end talents. In some cities, the construction of soft environment is not enough. It is also necessary to enhance the charm of the city and retain more talents.

Keywords—enterprise innovation, R&D team, innovative talents, talent policy, environmental construction

I. INTRODUCTION

The innovative ability of enterprises is mainly embodied in their ability to grasp and utilize advanced scientific and technological means, possess the research and development ability of high-end technology, be able to transform new technology into products, and produce world-class products that reach the international level. There is still a considerable gap between Chinese enterprises and world-class multinationals. Especially in Liaoning Province, there is a certain gap between R & D and domestic high-end enterprises. In the past 40 years of reform and opening up, the gap between Liaoning's economy and the developed provinces has increased. Apart from the unreasonable industrial structure, the short industrial chain and the backwardness of industrial policies, the reasons for this result are also related to the weak R&D capability of enterprises in Liaoning Province and the lack of technological advantages.

The purpose of this survey is to dissect the status quo of R&D team of some representative enterprises in Liaoning Province, and to conduct a follow-up survey to find out the relationship between R&D team building and the development of the business community, and then to find the possibility of improvement.

II. LITERATURE REVIEW

The R&D strength of enterprises is generally measured by R&D capital investment and R&D personnel investment. More in-depth indicators will involve deeper factors such as the accumulation of knowledge of R&D personnel, the knowledge flow of R&D teams, and the incentive mechanism of R&D teams.

The period of R&D intensity increasing from 1% to 2% is regarded as the transition period of technology innovation strategy from technology application country to innovation country. For enterprises, R & D intensity is also the most important indicator. A qualitative study in the world shows that R&D expenditure accounts for less than 1% of sales revenue, enterprises are difficult to survive; 2% can be barely maintained; more than 5% can be competitive. If measured in this standard, R & D personnel share the proportion of employees is also an important indicator to measure the R & D strength of enterprises[1]. Wu Xiaobo et al. (2003) believed that the proportion of R&D personnel in employees was positively correlated with R&D intensity, and the correlation coefficient was 0.939 ($P < 0.01$). But the proportion of R&D personnel varies with the nature of the enterprise. For example, the production system of software enterprises is small, and the proportion of R&D department in human resources is larger than that of traditional manufacturing enterprises.

Human capital theory holds that in the process of human capital reproduction, economic growth can be promoted through internal and external effects, and the return rate of human capital investment is much higher than that of material capital investment. The internal benefits of human capital should be accomplished through knowledge flow and knowledge updating within the enterprise. At the same time, [2] Nonaka, I (1995) argues that knowledge creation can occur both within and between groups by sharing tacit knowledge and producing cross-level knowledge. Empirical studies of Zhang Lifei, Zeng Deming and Zhang Yunsheng (2004) on motivating factors for R&D personnel show that learning and training have a significant effect on the incentive of R&D personnel (ranking in the top three). As the renewal and development of technology and knowledge in high-tech enterprises are explosive, accumulating and renewing knowledge is an effective way for R&D personnel to maintain a certain value of knowledge capital and competitive advantage.

The entrepreneurs should fully mobilize the enthusiasm of R&D personnel by means of material incentives and environmental incentives. Although the incentive process is not

linear, it is connected with each other. Environmental incentives create a more relaxed atmosphere for innovation, and the second is to provide more opportunities for innovation. [4] R & D personnel's desire for creating opportunities sometimes exceeds that of material incentives.

The knowledge flow of R & D team is related to the heterogeneity of R & D team. [5] The earliest question from the creative point of view is the founder of the comprehensive method Gordon, W.J. J., (1986). His understanding of group creativity is very original and profound and consciously aware of the role of group membership in group creativity. They choose different group members to adhere to different knowledge background and different emotional characteristics. In 1998, Lau and Murnighan[6] first proposed the concept of team fracture zone. The knowledge and expertise of the R&D team, as an important indicator of the fault zone, may be far more important than other indicators. [7] Some scholars also analyze problems from the perspective of enterprises, rather than limited to R & D teams.[8] Wan Xi (2007) believes that the important people in the human resources of innovative enterprises are the idea generating, entrepreneuring or championing, project leading. The proponents of the new vision in the first phase of R&D are key players, but in the later stages, entrepreneurial people are needed, but the coordination of the gatekeeper in the market, manufacturing and technology fields is required from beginning to end.

About the R&D performance of enterprises, [9] Zhang Yunsheng, Zeng Deming and Zhang Lifei (2004) think that the performance evaluation of R&D is mainly based on innovative indicators, such as the number of patents, participation in international standards, the number of authoritative papers published, the degree of technological leadership, etc. Financial efficiency indicators as option value participate in the performance evaluation of R&D. Performance control is mainly in the input point, output point and internal process management control.

Most of the research results of the government's investment in R & D have been positively affirmed.[10] Yang Xun and Shi Ping (2005) thinks that the leverage of government's technology input is greater than that of crowding out. [11] Becker and Hall (2003) divided the industry into two groups to study the determinants of R&D input, and found that government funding is only significant for low-tech industries, but not for high-tech industries. [12] Cheng Hua and Zhao Xiang (2008) found that the government's S&T funding has a significant effect on the R&D investment of low R&D intensity enterprises in the next year, but has a significant effect on the R&D investment of high R&D intensity enterprises in the same year through empirical research. The main force of R & D is still in the enterprise itself.

III. Survey Object, Survey Content and Survey Method

The empirical field survey method is adopted.

A. Respondents and time:

The object of this study is two large and medium-sized traditional manufacturing enterprises in Liaoning Province, one traditional metallurgical enterprise and one high-tech enterprise.

From December 1, 2006 to March 31, 2007, we visited and investigated several large and medium-sized enterprises and companies in Liaoning Province, including high-tech enterprise A, traditional manufacturing enterprise B, traditional manufacturing enterprise C and traditional metallurgical enterprise D. Two R&D teams were selected from each enterprise to conduct a questionnaire survey. A total of 47 participants participated in the survey. All the questionnaires were valid. And four leaders and R & D leaders of 11 enterprises were interviewed.

In 2011, four enterprises were re-traced.

B. Investigation contents:

①Investigate the status quo of scientific and technological personnel in enterprises, including the number of scientific and technological personnel, professional titles, post distribution, the flow of scientific and technological personnel, the training of scientific and technological personnel, etc.

② Investigate the R&D team situation, including the number of R&D team, investment (nearly three years), team professional, Title structure, R&D team mobility, and external contacts and cooperation.

③Tracking the output value, profit, R&D investment and core technology and product development of enterprises in the past three years from 2008 to 2010, this paper compares the importance of R&D team building three years ago and draws a conclusion.

C. Methods of investigation:

①Questionnaires were used to investigate the satisfaction of working environment and urban living environment.

②Interview. The purpose is to have a deeper understanding of the history of R&D team building, incentive policies, and the main problems of R&D team.

IV. Survey results

Traditional manufacturing enterprise B, traditional manufacturing enterprise C and traditional metallurgical enterprise D are all old enterprises of large state-owned heavy industry. Among them, the traditional manufacturing enterprises B and the traditional manufacturing enterprises C are the top 500 enterprises in China's manufacturing enterprises; the traditional metallurgical enterprise D has just completed the transformation, the enterprise is in a loss-making, and the innovation ability of the enterprise is weak; high-tech enterprise A is a new high-tech enterprise and is the first software enterprise that has passed CMM5 and CMMI (V1.2) 5 certification in China. The difference between the growth rate and economic benefit of these enterprises is more due to the difference between the innovation ability of the scientific and technological personnel and the R&D ability of the enterprises.

A. Overview of Scientific and Technological Personnel and R & D Teams in Enterprises

From chart 1, we can see that 80% of the scientific and technological personnel in high-tech enterprise A, 77.6% of the scientific and technological personnel engaged in research and development work, 31.1% of the scientific and technological personnel in traditional industry B, and 20.5% of the enterprise C; in traditional metallurgical enterprises, only 5.2% of the workers are D-technicians, of which only 9.7% are engaged in R&D, and the R&D team is weak, while 38.6% are engaged in management and sales.

TABLE I. STATISTICS OF THE STATUS OF THE SCIENTIFIC AND TECHNICAL PERSONNEL (2007 DATA)

Enterprise name	Total number of employees	Scientific staff							
		Number of people	Percentage	R & D personnel		Production of first-line scientific and technical personnel		Sales and management staff	
				Number of people	Percentage of scientific staff	Number of people	Percentage of scientific staff	Number of people	Percentage of scientific staff
Enterprise B	5352	1664	31.1%	330	19.8%	1184	71.2%	150	9.0%
Enterprise C	3185	653	20.5%	199	30.5%	188	28.8%	266	40.7%
Enterprise A	6000	5000	80%	3880	77.6%	495	9.9%	625	12.5%
Enterprise D	6108	319	5.2%	31	9.7%	165	51.7%	123	38.6%

B. R&D team organizational structure and external collaboration

TABLE II. SCIENCE AND TECHNOLOGY DEVELOPMENT SURVEY

Enterprise name	Research and development institution	R&D investment in sales in 2007	Cooperation with research institutes and enterprises at home and abroad
Enterprise B	Two centers: technology center, research and development center, Two design institutes	5.4%	Academician workstations and postdoctoral workstations of Tsinghua University, Dalian University of Technology, Northeastern University
Enterprise C	Two centers: technology center, research and development center, a research and development department, a design institute	5%	Established a research institute in cooperation with Dalian University of Technology; built a postdoctoral workstation with Northeastern University, Xi'an Jiaotong University, Zhejiang University, Mitsubishi, Siemens
Enterprise A	Divided into two level: Company-level R&D department Divisional R&D Department	2.5%	Northeastern University, Tsinghua University, Nanjing University, Huazhong University of Science and Technology Chinese Academy of Sciences
Enterprise D	One department: Technical Department	0.07%	Northeastern University Shougang

[13]Technological innovation is a network in which nodes mainly include social actors closely related to technological innovation activities. Therefore, technological innovation of enterprises is a common activity between enterprises and other actors. The external cooperation of enterprises has become the norm.

The enterprises interviewed cooperate with domestic research institutes, universities and enterprises in tackling key technical problems, especially those enterprises with good economic benefits and ranking in the forefront of the industry.

C. Enterprise R&D Personnel Knowledge Update and Talent Flow

TABLE III. ENTERPRISE SCIENCE AND TECHNOLOGY TALENT TRAINING AND TALENT FLOW (2005-2007)

Enterprise Name	Personnel training			Talent introduction				Brain drain
	Job Training (persons)	Study abroad (persons)	Training funding (ten thousand yuan)	Number of people	Overseas	College graduate	Other department	Number of people
Enterprise B	2785	483	754	462	54	284	124	19
Enterprise C	1242	325	90	589	3	528	61	32
Enterprise A	8474	726	1600	5049	0	5049	0	1999
Enterprise D	3100	24	100	133	0	133	0	21

The important method of knowledge renewal is enterprise training, and the exchange of tacit knowledge can also be compensated by skill training. As can be seen from Table 3, one of the reasons why high-tech enterprises have strong innovation ability is that they attach great importance to personnel training. The number of talents introduced by high-tech enterprises such as Enterprise A is large, and the outflow of talents is also large. Enterprise D, which is of general benefit, has only a small number of talents, and 81% of the brain drain is middle and senior talent.

V. MAIN PROBLEMS IN R & D TEAM DEVELOPMENT

A. Lack of High-end Innovative Talent

Respondents believe that the R&D team is gradually expanding, and the obvious problem is the lack of human resources. Besides, the most important thing is that people's innovation ability is poor and their quality can not keep up with the development needs. The policy of introducing talents is not prominent and the atmosphere is not strong enough to attract real talents. What R&D departments lack most are high-tech

knowledge, high-level R&D personnel trained strictly in scientific research, and compound talents who master high-tech to solve practical problems in production. It is difficult to break through the core technology in a short period of time because of the lack of experienced leaders to lead the R&D team to engage in the world's cutting-edge research. The first is that young people, though challenging, lack experience and are not competent for key jobs in a short period of time. Taking the iron and steel industry as an example, due to insufficient technical reserves and low R&D capability, Liaoning enterprises can not mass produce high-grade steel plates such as automobile panel and cold-rolled silicon steel which are badly needed in the market.

B. Unreasonable Internal Structure of R & D Team

The respondents of Enterprise a think that the main problem of the R&D team is the echelon problem of the R&D team, and the level is not clear. Each project is typically composed of a project manager, a technical architect, and other R&D personnel. Project managers are responsible for technical supervision, technical architects are responsible for organizational management, formulating technical strategies and risk prediction, but the current level of team members is not clear enough, resulting in inappropriate division of labor. There is no shortage of funds in the enterprise and no shortage of ideas. But it lacks talents, R&D management talents, and no suitable project manager, which is also the reason why the structure is unreasonable and the division of labor is not clear.

C. A More Vigorous Talent Policy Is Needed

The potential human capital of higher education in Liaoning has not been fully implemented in the actual economic operation. There are also many large enterprises do not take patents, technical standards, computer layout design and other intangible assets as technology shares to reward research and development personnel, resulting in serious loss of innovative talent and intellectual achievements. The loss of outstanding college graduates is still serious, and the outstanding talents needed by Liaoning's economic development are lack of supply and renewal. At present, the introduction of enterprise talents in Liaoning Province is mainly for college graduates, but the quality of undergraduates recruited is not as good as in previous years. Enterprise scientists and technicians are most concerned about the policy of introducing talents in Liaoning Province. They believe that the atmosphere of cherishing talents in Liaoning Province is not strong enough to attract real talents.

D. Enhance the Charm of the City and Attract More Talents

The satisfaction of the four enterprises surveyed is higher than that of the city. The interviewees believed that cities were mainly influential for young people, and young people preferred to go to the cities they liked. City managers can keep young talents only if they have more policies to attract talents.

VI. CONCLUSION

The construction of R & D team is an important factor in measuring the innovation capability of enterprises. The survey found that the lack of high-end talents in Liaoning enterprises is the biggest problem. Enterprise scientific and technological personnel are concerned about the policy of introducing talents and the construction of urban living environment in Liaoning Province. It shows that the construction of enterprise R&D team is not only an internal management problem, but also a problem of talent external environment construction. Enterprises in Liaoning Province are at a critical moment of transformation and upgrading, the purpose is also to enhance the innovative ability of enterprises, so the results of this survey for enterprise talent management and the adjustment of government talent policy have a certain practical significance.

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