An Implicit Evaluation Model of Innovation Environment: Test on a Survey of Technology Executives

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Objectives: Using the implicit theory and research method of psychology, to discuss inner demand and implicit evaluation on innovation environment from executives' opinion. Based on existing literature, enterprise testing and expert discussion, an innovative environmental evaluation index system was constructed from the perspective of senior executive psychology. On the Basis of the survey from 142 enterprises in china's western region, the results show that the innovation environment is in the "general" level, executives have the highest recognition of innovation culture, the best innovation atmosphere, the lowest satisfaction with innovation resources, especially innovation talents team and R&D investment. Compared with different types of enterprises, large and medium-sized enterprises are relatively good, and state-owned enterprises are better than non-state-owned enterprises.

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What are the drivers of innovation? Traditional ideas about innovation management focus almost entirely on internal factors, the ability and process to create and commercialize technology within the company. While the importance of these factors is undeniable, the external environment of innovation is just as important or more important. For example, the amazing innovation output of Israeli companies is not only because of more efficient technology management, but also because of Israel's favorable innovation environment, including strong university-industrial connections and large numbers of trained scientists and engineers. Even where innovation is most fertile, there are existing significant differences by field. During the 1990s, the United States had been a most attractive environment for pharmaceutical innovation, while Sweden and Finland have excelled in wireless technology innovation. Earlier studies found that the innovation tendency of enterprises is closely related to the characteristics of their country's innovation environment, and the impact of the number of scientific and technological personnel, the total research and development expenditure, the efficiency of intellectual property protection, the openness of international competition and the intensity of higher education expenditure on the national innovation output is very significant[1].

A point of view is proposed that the innovative activities and performance of talents are affected by individual ability and quality, and the environmental impact of cannot be ignored.[2] This study uses the implicit research method to discuss the demand and

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internal evaluation of the ideal innovation environment and its various characteristic elements. Implicit research is to explore concepts, structures, or perceptions formed by the general public in the context of daily life and work, and present in some form in the individual mind. Since American psychologist, Sternberg attempted to study the implicit view of intelligence, the method of implicit research has been gradually popularized.[3] China has introduced implicit research methods in some research fields, with typical ones such as implicit creativity theory, implicit leadership theory, etc., which further expands the scope of implicit research.[4,5] Implicit theory affects an individual's understanding and judgment of information, especially in adversity or adverse environments, affecting its subsequent emotional, behavioral and physiological responses.[6] Unlike laboratory experiments, implicit research has better ecological validity and is better reflected in the natural state of the inner views and tendencies that are their inherent desires.

Since the 1970s, researchers have found that some important innovation regions, such as Silicon Valley, Hsinchu and Taiwan, are characterized by a favorable innovation environment.[7] The competitive advantage of some new industrial zones in Europe and North America is believed due to the favorable innovation environment generated by the agglomeration of enterprises in the region.[8] The European Research Group on the Environment of Innovation (GREMI) first proposed the concept of the innovation environment as the place for innovative and innovative enterprises and an informal, complex social relationship established by behavioral subjects within a limited region through mutual synergy and collective learning processes. Many studies and practices have proved that almost every country or region with a relatively developed economy has a good environment for innovation.[9,10] This encourages us that we must pay great attention to the construction of the innovation environment, in order to improve the regional innovation capacity.

Since the European Research Group on the Innovation Environment (GREMI) proposed the concept of an innovation environment, research on innovation environment has gradually become a hotspot. More and more researchers realize that those non-material and non-trade factors in regional development have become increasingly important factors affecting the difference of regional development.[11,12,13] These factors constitute the content of regional innovation environment and become the basic conditions for regional innovation and the advantage to attract and retain various liquidity resources.[14] A good innovation environment includes a good hard environment and a soft environment for innovation, which is conducive to stimulating innovation and diffuse knowledge, helps to promote industrial integration and cross-breeding of innovation thus promotes international high-tech competition.[15] Therefore, it is worthwhile to explore how innovation subjects can interact with the environment, so that all kinds of models will eventually emerge at the macro level after the recombination.

The earlier research on related innovation environment focuses on conceptual defining, classifying the innovation environment, and exploring various factors affecting innovation environment. As such research gradually intestifies, evaluation of innovation environment becomes a new hot spot. Based on different research perspectives and methods, scholars have constructed different innovation environmental evaluation index systems, and launched a series of empirical studies. [16-18] The most impactful on innovation environment research involving national and regional competitiveness reports, such as the most influential international economic BBS released the world competitiveness report, Lausanne international management development annual report, Harvard university professor Potter completed and published innovation index research, the United Nations development program issued human development report etc., have special evaluation of the innovation environment. The most influential in China is China Regional Innovation Capacity Report issued by China Research Group on Science and Technology Development Strategy since 1999.[19,20] The report evaluates regional innovation environment from five aspects, innovation

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infrastructure, market environment, quality of workers, financial environment and entrepreneurial level.[21]

The relationship between innovative individuals and regional innovation environment has also become a research topic, and research perspective tends to be microscopic. When the environment provides sufficient innovation clues for individuals, innovation atmosphere, innovation resources, etc. individuals with innovation characteristics are more likely to express innovation intention or behavior, so different trait-related contexts have a promoting or inhibitory effect on trait expression or activation effect.[22] Some literature discusses the relevance of enterprises and talents with a innovation environment based on the theory of symbiosis. A study conducted by XuBin analyzed the symbiotic mechanism of small and medium-sized technology enterprises in the movement and reallocation of technology resource elements.[23] Another study by Peirong et al found from the perspective of the organizational imprint found that the enterprises established during the recession, under the continuous action of the imprint of resource shortage, tend to have conservative utilization innovation in the future, and the impact of this imprint weakens as the investment in innovation resources strengthens.[24] Their research also found that CEO with technical background can enhance enterprise innovation awareness and special risk preference for technology research and development. Furthermore, a mutualistic evolution model of scientific and technological talent agglomeration and regional innovation environment, is built to simulate the Xiongan New Area in Hebei, China.[25] Its results show that the stability of symbiotic evolution model depends on the Allee effect, agglomeration scale of scientific and technological talents and symbiosis coefficient in the region.

From the perspective of the current academic research, scholars' research on the innovation environment starts from the macro perspective, such as national and regional perspectives, as an aspect of reflecting competitiveness and innovation ability. The research from the micro perspective of enterprises and talents is gradually enriched and it begins to focus on the discovery of the inner needs of individuals in innovation activities for the innovation environment. In the construction of the evaluation index system, it focuses on the study of environmental elements such as the scientific and technological innovation investment, the measurement of scientific and technological innovation achievements, and the scientific and technological innovation infrastructure. From the psychological level, individual scholars discuss how people engaged in innovation activities can evaluate these innovation environmental elements that have been more studied, as well as the characteristics of this psychological evaluation and the reflection in innovation activities. This kind of microscopic perspective can better explain the imbalance and heterogeneity in progressive regional construction. The construction of innovation environment needs extensive attention and active participation from the bottom-up subjects of innovated activities. In particular, as an important indicator reflecting regional and national competitiveness and innovation ability, it should reflect the ideas and demands of innovative enterprises and people, so as to truly mobilize the whole society and achieve the goal of creating a good innovation environment, so as to achieve innovative development and improve competitiveness.

The main contribution of this study is: first, introduce implicit theory and research methods into the field of innovation environment and expand the theoretical and practical research of innovation environment; secondly, the six-dimensional evaluation model of their innovation environment is innovation culture, innovation resources, innovation policy, innovation services, technology finance and information network; finally, the situation of innovation environment is verified.

METHODS

Design

Based on the implicit theory and method, the evaluation model is constructed from the innovation environment support that executives expect to obtain from the enterprise innovation activities. The whole process is divided into three stages. In stage I, the

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initial questionnaire was first compiled, and the previous research was sorted out and summarized according to the initial framework of "regional innovation environment", so as to form the initial structure and item list of executive innovation environment evaluation. Secondly, with the support of the Science and Technology Bureau of the two development zones, we carried out research on more than 20 representative enterprises in the zone and conducted an open questionnaire survey. According to the original structure, write about 20 items, such as “What do you think of the innovation environment?” Or “what should it be?” in order to describe entries in an effective innovation environment. Summary results, screened against the frequency of behavioral or trait occurrence, were supplemented as the item to the initial scale. Then the two questions were summarized, after coding and classification, combined with the results discussed by the expert group, the content and structure of the implicit evaluation in the innovation environment were clarified, thus the "Innovation Environment Questionnaire" was designed accordingly, and all items are scored by Likert scale. Also detailed. In stage II, the implicit innovation environmental evaluation model was tested and determined. Using sample firms' survey and MBA students' interview, 40 people were selected for preliminary test, complete the pretest reliability and validity test, preliminary verification of the quality of the questionnaire and correction, and then the questionnaire was fully distributed. In the stage III, according to the survey data of enterprise executives' judgment on the importance of the characteristics of innovation environment, SPSS software is used for analysis and inspection, and the evaluation is carried out from 6 dimensions and 34 indicators.

Model

The investigation lasted more than a year, with high-tech enterprises in western China as the survey object, distributed 270 questionnaires in three rounds and recovered 142 effective questionnaires. They extensively collected, extracted layer by layer, scientifically constructed and verified an ideal innovation environment to evaluate the minds of entrepreneurs (see Table 1).The evaluation index system includes 34 evaluation indicators in 6 dimensions. Based on this evaluation index, this study builds an implicit evaluation model of enterprise executives on the innovation environment.

The questionnaire was designed first according to the evaluation indicators of Table 1.Use Likert scale, to judge the 34 indicators "very bad" to "very good" or "ineffective" to “very effective” features of the innovation environment. The questionnaire was distributed to high-tech executives, with a total of 272 questionnaires and 160, with recovery rate of 58.8% and 141 valid questionnaires of 88.7% (see Table 2 for statistical variables of valid questionnaire).

Measures

Using IBM SPSS for exploratory factor analysis of survey data, 34 items were clearly attributed to 6 structural dimensions, further reliability analysis, validity analysis, overall Cronbach's Alpha coefficient is 0.772, good overall credibility, stable and reliable; KMO value is 0.704, Bartlett test result P value <0.05, indicating that the questionnaire data is suitable for factor analysis and the questionnaire is valid. It can be seen that the innovation environment in the mind of enterprise executives is a comprehensive network system, vast in content, which can reflect the internal and external environment perceived by enterprises when engaged in innovation activities, and the sum of various factors conducive to guiding and stimulating enterprise innovation activities and improving the innovation ability of enterprises.

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Table 1
Evaluation Index System of Innovation Environmental

Evaluation dimension	Evaluation indicators	Indicator coding	Evaluation dimension	Evaluation indicators	Indicator coding
Innovation culture	Technical strategy / plan is effective	B1	Innovation policy	Preferential tax policies for R&D expenses	D1
	Relationship between R &D Department and Sales Department	B2		Income tax reduction and exemption policy for high-tech firms	D2
	Employee's sense of identity with the enterprise	B3		Accelerated depreciation policy for special instruments and equipment for R&D	D3
	Innovation atmosphere	B4		Science and technology development products exempted from import tax policy	D4
	Equity incentive	B5		Incentives for attracting and cultivating talents	D5
	Compensation incentive	B6		Support policies for high-tech industries	D6
	Material rewards such as car / housing	B7		Improvement of intellectual property policies and regulations	D7
	Jin job award	B8		Preferential tax policies such as technology development and transfer	D8
	Training / further Study opportunities	B9		Preferential policies of Development zone	D9
Innovation resources	Entrepreneurial innovation spirit	C1	Innovative services	Support degree of science and technology intermediaries	E1
	Innovation capital input	C2		Intermediary service expenses	E2
	High-quality innovation team support	C3		Intellectual property trading market	E3
	Technology R&D center	C4	Science and technology finance	Bank credit	F1
	Innovation cooperation	C5		Venture capital	F2
	Mechanism for maintaining competitiveness	C6		Support of guarantee institutions	F3
	Government spending on science and technology	C7	Information network	Enterprise Information Network	G1
	Cooperation mechanism with scientific research institutions	C8		Government information service platform	G2

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Table 2
Socio-demographic Characteristics of Participants

Statistical variables	Education background	Number of Executives	Occupy	Statistical variables	Education background	Number of Executives	Occupy
Gender	Male	90	63.84%	**Age**	<is 40 years old	52	36.6%
	Female	52	36.16%		> is 40 years old	90	63.4%
Education	Dr	4	2.8%	**Enterprise category**	State-owned enterprises	25	17.6%
	Master's degree	24	16.9%		Private enterprises	100	70.4%
	Undergraduate course	84	59.2%		Foreign-funded enterprises	2	1.5%
	College	30	21.1%		Other	15	10.5%

The satisfaction ratio of each index was counted according to 142 valid questionnaires and taken as the corresponding membership of each index, so as to determine the fuzzy evaluation matrix of each index. The specific calculation steps are: (1) evaluate 6 dimensions (innovation culture, innovation resources, innovation policy, innovation service, technology finance, information network); (2) takes 6 dimensions fuzzy evaluation set as fuzzy evaluation matrix of overall evaluation of enterprise executive innovation environment, fuzzy comprehensive evaluation, obtains the final fuzzy evaluation set; (3) quantified the fuzzy evaluation set and calculates the comprehensive score.1 Represents “very bad”, 2 “not very good”, 3 “general”, 4 “better” and 5 “very good”. For example, the evaluation matrix of the calculated innovation resources is:

$$R_1 = \begin{bmatrix} 0.032 & 0.130 & 0.542 & 0.227 & 0.045 \\ 0.112 & 0201 & 0.443 & 0333 & 0.089 \\ 0.063 & 0.142 & 0.410 & 0.321 & 0.067 \\ 0.042 & 0.155 & 0.456 & 0.304 & 0.056 \\ 0.032 & 0.167 & 0.383 & 0.365 & 0.063 \\ 0.011 & 0.189 & 0.405 & 0.387 & 0.082 \\ 0.022 & 0121 & 0.388 & 0.327 & 0.064 \\ 0.035 & 0128 & 0.396 & 0.311 & 0.074 \end{bmatrix}$$

The normalized weights of the 8 secondary indicators of the innovation resources are as follows:

$$\omega_1 = [0.088 \quad 0.082 \quad 0.079 \quad 0.065 \quad 0.092 \quad 0.114 \quad 0.233 \quad 0.115]$$

Then the fuzzy evaluation set of the innovative resources was calculated separately using the weighted averaging model as:

$$[0.033 \quad 0.129 \quad 0.363 \quad 0.281 \quad 0.058]$$

Following this calculation, the fuzzy evaluation set of 6 dimensional 34 metrics and the overall status quo, further calculating the corresponding comprehensive scores and ranking (see Table 3).

Table 3
Evaluation results

Innovation environment	score	Sorting	Innovation environment	score	Sorting	Innovation environment	score	Sorting	Innovation environment	score
Innovation culture	3.402	1	Innovation policy	3.227	3	Science and technology finance	3.303	2	Comprehensive condition	3.162
Innovation resources	3.001	6	Innovative services	3.023	5	Information network	3.112	4		

RESULTS

Overall

Survey executives had the relatively highest reviews of innovative culture. From the nine metrics

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in this dimension, the best is "innovation atmosphere" (B4), "technology strategy/plan effective" (B1), 91.5% of enterprises encourage innovation, 44.0% have perfect innovation mechanism, 77.3% strongly encourage innovation and develop a strong support system. Survey executives believe that "Research and Development and Sales Relations" (B2) "training / further opportunities" (B9) is "better", 80.8% of enterprises have formed a continuous training culture, 85.1% of enterprises trained technical personnel, training content mainly involves technology, management and safety knowledge; 22.0% of research and marketing communication, 22.0% said "smooth", 61.0% said "more smooth", indicating that most enterprises focus on the market.

Survey executives had the lowest evaluation of innovation resources. The membership of "general" is close to 50% and "insignificant" is 20.2%, reflecting the weak funds and human resources provided by the survey enterprise region in ensuring scientific and technological innovation. From the perspective of 8 indicators in this dimension, the general evaluation is low, 8 indicators are all below 3 points, relatively good is "entrepreneurial innovation" (C1), score higher than 3 points, believing that entrepreneurs are "very innovative" and "innovative" executives accounted for 16.2% and 46.6%, respectively. "High Quality Innovation Team Support" (C3), "Innovation Funding Investment" (C2) Lack, with about 30% and 28% of corporate executives as "insufficient". There is also a lack of "mechanism for maintaining competitiveness" (C6), which is considered "insufficient" by about 20% of corporate executives. Patent application is the main measure (see Table 4). Some senior executives have proposed that more policy support and financial encouragement should be given to the training of high-quality talents and the introduction of talents and technology. In addition, the concept of market network expansion, dealer cooperation, honest management, enterprise research and development organization management also have an obvious impact on the success rate of innovation.

Table 4
Measures Maintaining Competitiveness

Items	Survey statistics	Items	Survey statistics
Apply for patent	89.36%	Apply for copyright registration	25.53%
Apply for registered trademark	68.09%	Form national or industrial technical standards	45.39%
Protect the technical secrets	64.54%	Apply complex techniques difficult to replicate	10.64%
Accelerate technology innovation to maintain technology ahead	63.12%	Play the first-mover advantage	17.73%
Disprove the parts processing channels to prevent imitation	14.18%	Sign contracts or disperse research to control the researchers	9.94%

Survey executives have received relatively good reviews of technology finance. From the three metrics in this dimension, "bank credit" (F1) dominates, 78.0% of enterprises seek bank loan support, 15.6% seek financial assistance, and "venture capital" (F2) is very scarce. The "very easy" evaluation of "bank credit" (F1) and "relatively easy" membership were 9.93% and 23.4% respectively, and "generally" membership were 49.6%, indicating that the banking industry has good support for high credit. In terms of the main factors restricting financing, the "government support policy" and "effective fixed asset mortgage" rank the first.

Executives' evaluation of the innovation policies is relatively in the middle. In terms of preferential government policies, tax, financial appropriation/subsidy /reward system dominate, among which the rate of enterprises that have enjoyed preferential tax and financial appropriation/subsidy/reward system has reached 85.82%, and few enterprises have enjoyed incubation, land preference and government procurement. According to the survey results, in

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comparison, the "innovation incentives" of "Income Tax Reduction Policy" (D2), "Priority Industrial Development Support Policy" (D6) had "significant results", recognized by 56.03% and 43.97% of executives, respectively, while up to 75.9% of executives deemed "technology development supplies exemption from import tax policy" (D4) "ineffective".

Of the 34 evaluation indicators, the two most lacking indicators that senior executives thought were "High-quality Innovation Team Support" (C3), "Innovation Funding Investment" (C2). According to the statistical results of "main factors attributing to the success of innovation" (as shown in Table 5), talent and capital are the two main factors restricting the development of scientific and technological innovation in the surveyed region.

Table 5
Main Factors Attributing to the Success of Innovation

Items	Survey statistics	Items	Survey statistics
High-quality talents	**92.20%**	Innovative entrepreneurs	**85.82%**
Sufficient funding support	**83.69%**	Employee loyalty	75.89%
Internal corporate incentives	73.76%	The government has provided preferential policy support	78.01%
unimpeded information channels	74.47%	Effective technical strategy / planning	66.67%
Dependable innovation partners	46.81%		

Comparison

From the perspective of the executive evaluation scores of enterprises of different properties, state-owned enterprises are higher than other enterprises and private enterprises, among which two foreign-funded enterprises are negligible, indicating that the innovation environment of state-owned enterprises is relatively the best and private enterprises are the worst. By comparison, the best "innovation atmosphere" (B4) index, state-owned enterprises are higher than other enterprises and private enterprises; the most lacking "high-quality innovation team support" (C3), "Innovation Funding Investment" (C2), SOEs are lower than non-SOEs.

From the executive evaluation scores of different educational backgrounds, the "below the university" executives evaluate the innovation environment higher than the highly academic executives. "Below the University" executives see the least satisfactory innovation environment as the lack of "innovation funding" (C2), the least dissatisfaction of "University and above" executives was "High Quality Innovation Team Support" (C3).

From the perspective of the evaluation scores of executives of enterprises of different sizes, large and medium-sized enterprises are higher than small and medium-sized enterprises, especially in the dimensions of "innovation resources", "innovation policy" and "technology finance", the evaluation of small and medium-sized enterprises is significantly lower.

DISCUSSION

This study uses the implicit theory and implicit method of psychology, to construct and test the tools of individual executives to evaluate the innovation environment, and try to study the innovation environment of the enterprise. The conclusion shows: (1) on the whole, the enterprise innovation environment in the survey area is at the "general" level, and the surveyed executives have relatively high recognition of innovation culture and technology finance, with the lowest satisfaction with innovation resources.(2) From the perspective of the evaluation scores of senior executives of different properties, "state-owned" enterprises are relatively high, indicating that the innovation environment of "state-owned enterprises" is relatively the best and "private enterprises" have the worst innovation environment.(3) From the perspective of executive

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evaluation scores of different educational backgrounds, executives of "below universities" evaluate more of the innovation environment than those of senior qualifications, indicating that high-level executives have more demands for the improvement of the innovation environment.

According to the research results, weak quality innovation team and insufficient innovation investment are the key problems restricting the construction of an enterprise innovation environment; it is an important way to optimize the internal innovation environment; private enterprises are relatively weak and disadvantages in "innovation resources", "innovation policy" and "technology finance". Therefore, the relevant government departments should pay more attention to optimizing the innovation environment, one is to provide strong dynamic support for the remuneration of scientific and technological personnel, establish a long-term mechanism to introduce high-quality talents explore more flexible material reward mechanism, and the third is to carry out the construction of leading innovation activities to provide practical guidance for more scientific and technological talents to engage in innovation activities.

Study Limitations

Our study has some limitations. Firstly, we select an under-development province in western China and focus on the characteristics of enterprises' innovation activities in a relatively unfavorable innovation environment. Taking high-tech enterprises as the investigation object, the research sample is small, which has typicality but also has deviation. Therefore, future research suggests selecting more regions and a wider range of enterprise groups. In addition, the questionnaire design does not involve the technical executives' evaluation on the innovation behavior characteristics of their own and their partners, which may ignore the important factors affecting enterprise innovation activities, thus providing new clues for the research results.

Implications for Practice and Suggestions for Future Research

Technical executives are responsible for innovation activities, their implicit evaluation of the internal and external environment of the enterprise may have a long-term potential impact on enterprises' innovation activities. In less developed areas with resource constraints, enterprises' innovation activities are not active, so government support and enterprises' internal incentive are particularly important. However, even in the most physically deprived areas, strong government support and corporate ambition can enable technology to transcend resource constraints and become a powerful technology. In the growth process of enterprises, it is necessary to encourage each other between innovation environment and internal innovation power. As a government, we should actively foster a dynamic environment for innovation, and as an enterprise, we should be proactive and dare to break through adversity.

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Author Declaration

The authors declare no sponsored financial sources by any organization related to tobacco production for the undertaken study.

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