An AHP Evaluation Approach for Financial Ecological Environment of Scientific & Technological Small-Medium Enterprises
一A Case Study in South Central China

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Abstract — In order to evaluate the financial ecological environment of scientific and technological small-medium enterprises, this paper selects index from five aspects, such as the economic environment, direct financial environment, indirect financial environment, policy environment and technological environment. By using the analytic hierarchy process (AHP) method, an index system of financial ecological environment evaluation for scientific and technological small-medium enterprises is built and the corresponding evaluation model is established. As a case study, with the technological support of geographic information system(GIS), the proposed approach is applied to evaluate and analyze the financial ecological environment of scientific and technological small-medium enterprises in south-central China. It is shown that the AHP approach proposed in this paper can effectively and visually evaluate the financial ecological environment of scientific and technological small-medium enterprises.

Keywords - financial ecological environment, evaluation approach, AHP, small-medium enterprises, scientific and technological enterprises, South Central China, GIS

I. INTRODUCTION

Scientific and technological small-medium enterprises （STSMEs） are the knowledge intensive economic entities, with the main members of scientific and technological personnel, which engaged in scientific research, development, production, sales of high-tech products, technical development, technical services and technical advice. Because of the less assets, high risk, long-time investment, financial difficulty is the bottleneck of these enterprises development. In order to solve the financial problem, we should make an objective and comprehensive evaluation of the financial ecological environment.

At present, most studies about financial problem of scientific and technological small-medium enterprises focused on funds availability, one aspect of the financial environment, or describing status quo of financial difficulties and putting forward some specific measures[1][2], lack of comprehensive evaluation index system for financial ecological environment of these enterprises. The paper use the analytic hierarchy process(AHP) method to construct the evaluation index and establish an evaluation model on financial ecological environment of scientific and technological small-medium enterprises. Taking five provinces in south-central China as examples, the paper evaluates and analyzes the financial ecological environment of scientific and technological small-medium enterprises in south-central China, combined with the technology of geographic information system to visually show the classification results of various regional evaluation.

II. CONSTRUCTION OF EVALUATION INDEX SYSTEM

There are many factors that affect the finance of scientific and technological small-medium enterprises，which are embodied in the aspects of economic development, financial level, credit level, government policy and scientific development. So the financial ecological environment of scientific and technological small-medium enterprises could be considered as a comprehensive system, which contains five aspects of economic environment, direct financial environment, indirect finance environment, policy environment and technological environment[1][3][4][5]. Considering the principle of stability, the maximum contribution, manipulability, combined with a number of expert opinions, the most representative indicators will be selected from lots of influencing factors. In order to ensure the comparability and consistency of the evaluation indicators, the relative indexes such as total growth rate index, per capita amount, specific gravity indicator will be used for evaluation on financial ecological environment of scientific and technological small-medium enterprises, such as Figure 1 and Table Ⅰ.

A. Economic environment index.

Domestic and foreign practice shows that the higher level of economic development, the more abundant the financial resources available[6], and the more favorable to the survival and development of scientific and technological
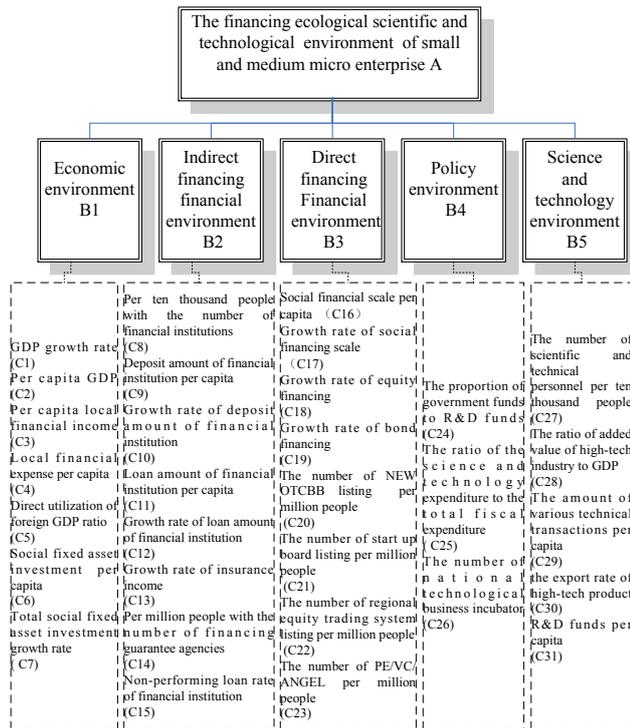
Figure 1. The evaluation index system of financial ecological environment of STSMEs.

small-medium enterprises, so the development and stability of regional economic should be considered.

Although there are many indicators that could describe economic, the paper focus on the ones that represent the influence factors closely-related with the finance of the enterprises, such as economic gross, sustainable development ability, economic openness and so on. The paper select seven indexes that are the GDP growth rate, per capita GDP , per capita local financial income, local financial expense per capita, direct utilization of foreign GDP ratio, social fixed asset investment ,per capita total social fixed asset and investment growth rate to evaluate economic environment.

B. Indirect financial environment index.

Indirect finance means that scientific and technological small-medium enterprises obtain loans from banks or other financial institutions. Indirect financial environment involve numbers of banks, insurance agents, financial guarantee institutions. To assess whether the indirect financial channels are smooth, it is necessary to investigate the number of overall financial institutions, balance sheets of banks, the development level of insurance, credit guarantee status and so on. The paper selects eight indexes that are per ten thousand people with the number of financial institutions, deposit amount of financial institution per capita, growth rate of deposit amount of financial institution, loan amount of financial institution per capita, growth rate of loan amount of financial institution, growth rate of insurance income, per million people with the number of financial guarantee agencies, non-performing loan rate of financial institution to evaluate the indirect financial environment.

TABLE I. THE CALCULATION FORMULA OF EVALUATION INDEX OF FINANCIAL ECOLOGICAL ENVIRONMENT OF STSMES

Index layer	Calculation formula
GDP growth rate C1	(GDP of reporting period - GDP of base period) / GDP of base period *100%
Per capita GDP C2	Total GDP of reporting period/ Total population of the report period
Per capita local financial income C3	local financial income of reporting period / Total population of the report period
Local financial expense per capita C4	Local financial expenses during the reporting period / Total population of the report period
Direct utilization of foreign GDP ratio C5	Total direct utilization of foreign capital during reporting period/ Total GDP of reporting period
Social fixed asset investment per capita C6	Total social fixed asset investment of reporting period / Total population of the report period
Total social fixed asset investment growth rate C7	（Total social fixed asset investment of reporting period - Total social fixed asset investment of base period） / Total social fixed asset investment of base period *100%
Per ten thousand people with the number of financial institutions C8	Total number of regional financial institutions during the reporting period / Total population of the reporting period *10000
Deposit amount of financial institution per capita C9	Deposit amount of financial institution during reporting period / Total population of the reporting period
Growth rate of deposit amount of financial institution C10	(Deposit amount of financial institution during reporting period - Deposit amount of financial institution during base period)/ Deposit amount of financial institution during base period *100%
Loan amount of financial institution per capita C11	Loan amount of financial institution during reporting period/ Total population of the reporting period
Growth rate of loan amount of financial institution C12	(Loan amount of financial institution during reporting period - Loan amount of financial institution during reporting period） / Loan amount of financial institution during base period *100%
Growth rate of insurance income C13	(Insurance income during reporting period - Insurance income during base period)/ Insurance income during base period *100%
Per million people with the number of financial guarantee agencies C14	the number of financial guarantee agencies during reporting period / Total population of the report period *1000000
Non-performing loan rate of financial institution C15	Non-performing loan amount of financial institution during reporting period/ Loan amount of financial institution during reporting period *100%
Social financial scale per capita C16	Social financial scale during the reporting period/ Total population of the report period

Growth rate of social financial scale C17	（Social financial scale during the reporting period -- Social financial scale during the base period）/ Social financial scale during the base period *100%
Growth rate of equity finance C18	(Equity finance scale during reporting period - Equity finance scale during base period) / Equity financial scale during base period *100%
Growth rate of bond finance C19	(Bond finance scale during reporting period - bond finance scale during base period) /bond financial scale during base period *100%
The number of NEW OTCBB listing per million people C20	The number of NEW OTCBB listing during reporting period/Total population of the reporting period *1000000
The number of start up board listing per million people C21	The number of start up board listing during reporting period/Total population of the reporting period *1000000
The number of regional equity trading system listing per million people C22	The number of start up board listing during reporting period/Total population of the reporting period *1000000
The number of PE/VC/ANGEL per million people C23	The number of PE/VC/ANGEL during reporting period/ Total population of the reporting period *1000000
The proportion of government funds to R&D funds C24	Government funds of R&D funds during reporting period / R&D funds during reporting period *100%
The ratio of the science and technology expenditure to the total fiscal expenditure C25	Science and technology expenditure during reporting period / Total fiscal expenditure during reporting period
The number of national technological business incubator per million people C26	The number of national technological business incubator during reporting period/ Total population of the reporting period *1000000
The number of scientific and technical personnel per ten thousand people C27	The number of scientific and technical personnel during reporting period / Total population of the reporting period *10000
The ratio of added value of high-tech industry to GDP C28	Added value of high-tech industry during reporting period/ GDP during reporting period*100%
The amount of various technical transactions per capita C29	The amount of Various technical transactions during reporting period/ Total population of the reporting period
the export rate of high-tech product C30	The amount of high-tech product exporting during reporting period /he amount of various products exporting during reporting period*100%
R&D funds per capitaC31	R&D funds during reporting period / Total population of the reporting period

C. Direct financial environment index.

Direct finance means the enterprises access to capital from the multi-layer capital market, containing equity finance and bond finance. By equity finance, scientific and technological small-medium enterprises could obtain funds by NEW OTCBB, start up board, regional equity trading system, private equity (PE), venture capital (VC) ,angel and so on. The bond finance for scientific and technological small-medium enterprises includes issuing corporate private bonds, short-term corporate bonds, enterprise collective bonds, enterprise collective notes, etc. In the future, the multi-layer capital market will be the most important financial channel for scientific and technological small-medium enterprises[7][8]. The paper chooses the social finance scale per capita, growth rate of social finance scale, growth rate of equity finance, growth rate of bond finance, the number of NEW OTCBB listing per million people, the number of start up board listing per million people, the number of regional equity trading system listing per million people, the number of PE/VC/ANGEL per million people as the indicators that represent the direct financial environment.

D. Direct financial environment index.

Policy environment represents the government support for scientific and technological small-medium enterprises. These enterprises are the main carriers for driving innovation, due to their high risk of investment. It is decided that the government should play the leading role on solving the financial problem of scientific and technological small-medium enterprises. The promotion measures by government includes establishing special funds, tax relief, building technology business incubators providing quality service for the enterprises venture, finance and management. In the paper, the three indexes of the proportion of government funds to R&D funds, the ratio of the science and technology expenditure to the total fiscal expenditure, the number of national technological business incubators per million people are selected to judge the policy environment.

E. Technological environment index.

The United Nations of the OECD believes that a country's scientific and technological enterprise environment usually can be measured by the following indexes such as the social economic development level, material infrastructure and support equipment, scientific and technical personnel, funding for research on stock, the scientific and technological level of production and manufacturing system, the reserve capacity of scientific and technological knowledge and information, scientific and technological situation, strength and policy in one certain field[1][9]. In this paper, the five indexes which are the number of scientific and technical personnel per ten thousand people , the ratio of added value of high-tech industry to GDP, the amount of various technical transactions per capita, the export rate of high-tech product, R&D funds per capita, are chosen to evaluation

III. AHP-BASED EVALUATION APPROACH FOR FINANCIAL ECOLOGICAL ENVIRONMENT OF STSMES

A. Establishment of evaluation index weight

The weight of index represents influence degree of the index on evaluation object. The author uses the evaluation methodology of Analytic Hierarchy Process (AHP) to assign weights to each index. AHP is a multi-level weight decision method with highly logical and systematic, which is proposed by scientist L.T.Saaty of University of Pittsburgh. The weight matrix of the index is obtained by the indexes pairwise comparison, and weight coefficient is acquired by calculating the matrix.

The author adopts many expert advices by questionnaire survey, according to the AHP method, establishes weight matrixes of various levels for financial ecological environment of scientific and technological small-medium enterprises.

Using MATLAB to calculate the weight matrix, get all the weight coefficient of the indicators such as tableⅡ.

TABLE II. THE INDEX WEIGHT COEFFICIENT OF FINANCIAL ECOLOGICAL ENVIRONMENT OF STSMES

Index layer	C-A Weight	Index layer	C-A Weight	Index layer	C-A Weight
C1	0.00141596	C12	0.02436212	C23	0.05623413
C2	0.01253747	C13	0.00944916	C24	0.03291489
C3	0.00635626	C14	0.02436212	C25	0.16457445
C4	0.01253747	C15	0.00944916	C26	0.16457445
C5	0.00141596	C16	0.12441756	C27	0.02139696
C6	0.00321703	C17	0.02364513	C28	0.0081534
C7	0.00141596	C18	0.010863	C29	0.02139696
C8	0.00445139	C19	0.010863	C30	0.0038481
C9	0.02436212	C20	0.05623413	C31	0.02139696
C10	0.00944916	C21	0.02364513		
C11	0.05481477	C22	0.05623413		

B. Establishment of evaluation grade

In this paper, the quantitative classification method is adopted to divide the financial ecological environment of scientific and technological micro enterprises into five grades. According to the analysis of the indicators affecting the financial environment, the following classification index system is obtained.

TABLE III. THE INDEX GRADE OF FINANCIAL ECOLOGICAL ENVIRONMENT EVALUATION FOR STSMES

Index layer	1	2	3	4	5
C1	a>10	(7.5,10]	(5,7.5]	[2.5,5]	<2.5
C2	>60000	(45000,60000]	(30000,45000]	[15000,30000]	<15000
C3	>7000	(5500,7000]	(4000,5500]	[2500,4000]	<4000
C4	>7000	(5500,7000]	(4000,5500]	[2500,4000]	<4000
C5	>800	(600,800]	(400,600]	[200,400]	<200
C6	>40000	(30000,40000]	(20000,30000]	[10000,20000]	<10000
C7	>20	(15,20]	(10,15]	[5,10]	<5
C8	>2	(1.5,2]	(1,1.5]	[0.5,1.0]	<0.5
C9	>100000	(75000,100000]	(50000,75000]	[25000,50000]	<25000
C10	>10	(7.5,10]	(5,7.5]	[2.5,5]	<2.5
C11	>60000	(45000,60000]	(30000,45000]	[15000,30000]	<15000
C12	>10	(7.5,10]	(5,7.5]	[2.5,5]	<2.5
C13	>10	(7.5,10]	(5,7.5]	[2.5,5]	<2.5
C14	>5	(4,5]]	(3,4]]	[2,3]	<2
C15	<0.5	(0.5,1]	(1,1.5]	[1.5,2]	>2
C16	>10000	(7500,10000]	(5000,7500]	[2500,5000]	<2500
C17	>10	(7.5,10]	(5,7.5]	[2.5,5]	<2.5
C18	>10	(7.5,10]	(5,7.5]	[2.5,5]	<2.5
C19	>10	(7.5,10]	(5,7.5	[2.5,5]	<2.5
C20	>20	(15,20]	(10,15]	[5,10]	<5
C21	>10	(7.5,10]	(5,7.5]	[2.5,5]	<2.5
C22	>400	(300,400]	(200,300]	[100,200]	<100
C23	>15	(10,15]	(5,10]	[1,5]	<1
C24	>20	(15,20]	(10,15]	[5,10]	<5
C25	>10	(7.5,10]	(5,7.5]	[2.5,5]	<2.5
C26	>4	(3,4]	(2,3]	[1,2]	<1
C27	>40	(30,40]	(20,30]	[10,20]	<10
C28	>10	(7.5,10]	(5,7.5]	[2.5,5]	<2.5
C29	>1000	(750,1000]	(500,750]	[250,500]	<250
C30	>10	(7.5,10]	(5,7.5]	[2.5,5]	<2.5
C31	>1000	(750,1000]	(500,750]	[250,500]	<250

C. Evaluation model

According to the above index system and the weight of each index, the comprehensive index evaluation method is used to establish the comprehensive assessment model of financial environment for scientific and technological small-medium enterprises:

$$S_j = \sum W_i F_i \qquad (1)$$

In formula, S_j is the final index score of financial environment for scientific and technological small-medium enterprises, W_i is the weight of the i-th index relative to the financial ecological environment, and F_i is the index score for the i-th index corresponding to evaluation grade.

TABLE IV.   THE EVALUATION GRADE OF FINANCIAL ECOLOGICAL ENVIRONMENT OF STSMEs

Grade	Excellent	Good	General	Poor	Very poor
S_j	<3.00	(3.00,4.00]	(4.00,5.00]	(5.00,6.00]	>6.00

Concrete evaluation steps are as follows: Firstly, calculate relative index according to the formula in Table Ⅰ by using factual data, and find the corresponding index grade in table Ⅲ; Secondly, find the weight of the corresponding index in table Ⅱ, and use the comprehensive assessment model of financial environment above to calculate the final indexes score; Thirdly, compare the final indexes score with evaluation classification standard in table Ⅳ, and get the final evaluation grade of the appraised region.

IV. CASE STUDY IN SOUTH CENTRAL CHINA

A. Data sources and preprocessing

Five provinces in Central South of China that are Hubei province, Hunan province, Guangdong province, Guangxi province, Henan province, are selected as evaluation areas. These five provinces financial ecological environment of scientific and technological small-medium enterprises in 2014 will be evaluated. The original data were collected from the provinces statistical communique on national economy and social development, statistical yearbook, wind information platform, financial office, economic and information technology commission, local customs, etc.. According to formulas in table Ⅰ, the index table of five provinces in 2014 is obtained.

TABLE V.   EVALUATION INDEX DATA OF FINANCIAL ECOLOGICAL ENVIRONMENT OF STSMEs IN FIVE PROVINCES OF SOUTH CENTRAL CHINA IN 2014

Index layer	Hunan province	Hubei province	Guangdong province	Guangxi province	Henan province
C1	9.5	9.7	7.8	8.5	8.9
C2	40287	47193	63452	33090	37118
C3	3354.41	4413.51	7515.91	4548.59	2902.15
C4	5024.5	5008.85	9134.33	3475.92	6042.60
C5	152.44	136.32	250.57	21.06	158.19
C6	32581.49	41786.54	24177.63	29119.08	32622.04
C7	19.4	20.4	15.9	16.3	18
C8	1.36	1.26	1.50	1.22	1.29
C9	44908.27	62749	119247.92	42697.81	43847.93
C10	12.6	10.8	6.9	10.3	11.7
C11	30848.28	43483.18	79188.54	33805.11	28855.73
C12	13.8	15.6	12.2	14.1	17.9
C13	15.6%	19.2	23.1	13.7	13.1
C14	2.20	5.14	3.36	3.91	2.89
C15	1.53	1.25	1.39	1.17	1.42
C16	5855.55	10046.42	12787.21	6539.76	7236.12
C17	-5.28	-4.6	-4.72	11	19.98
C18	-14.3	4.45	123.83	514.29	4.93
C19	38.18	36.75	103.34	110.16	-6.39
C20	7.27	19.94	23.22	2.52	9.22
C21	1.78	2.24	8.02	0	0.85
C22	46.31	92.85	413.28	41.02	43.03
C23	1.78	2.58	16.69	0.63	0.74
C24	14%	6.54%	4.06	27.69	12.92
C25	1.17%	1.53%	4.00%	0.52%	0.38%
C26	2.37	4.99	4.01	1.47	2.01
C27	18	32	48	8	24
C28	19.03%	16.3%	31.94%	18.64%	22.58%
C29	145.02	1034.63	506.48	24.36	44.13
C30	12%	24.4	21.46	11.8	56.25
C31	419.52	876.89	1517.16	7.55	423.91

Note：C1,C2,C3,C4,C5,C6,C7,C9,C10,C11,C12,C13 original data from the five provinces statistical bulletin of national economic and social development in 2014;C8,C15,C16,C17,C18,C19,C20,C21,C22,C23 original data from Wind information platform;C14 original data from the five provincial financial office or the economic and Information Commission;C24,C25,C27,C28,C29,C31 original data from statistical yearbook or statistical yearbook of science and technology of the five provinces in 2014;C26 original data from torch high tech Industrial Development Center of science and technology;C30 original data from the five provinces statistical bulletin of national economic and social development in 2014 or customs. The processing method of defect data: select the average of the previous year's data as an alternative.C15 the defect data in 2014 is replaced by the average data from 2009 to 2013；C24,C25,C31 some provincial defect values are replaced by the average values from 2011 to 2013.Defect numerical processing method: according to the principle of "if the missing value is a numeric type, according to the attribute value in the average of all other objects value to fill the missing attribute value"[10], selected in front of more than the data of the year of average values as a substitute.C15 uses five provinces 2009-2013 data average, C25, C31, C24 in individual provinces data missing are 2011-2013 years of data average, C24 2011 missing data from 2010 to replace.

B. Distribution of evaluation scores

Hunan Province, the final index score of 3.67 in good grades; Hubei province finally scored 2.88 points in excellent grade; Guangdong Province, score of 1.90, in excellent grade; Guangxi Province, the final score of 3.78 in good grades; Henan province finally scored 3.62 points, in the good level.
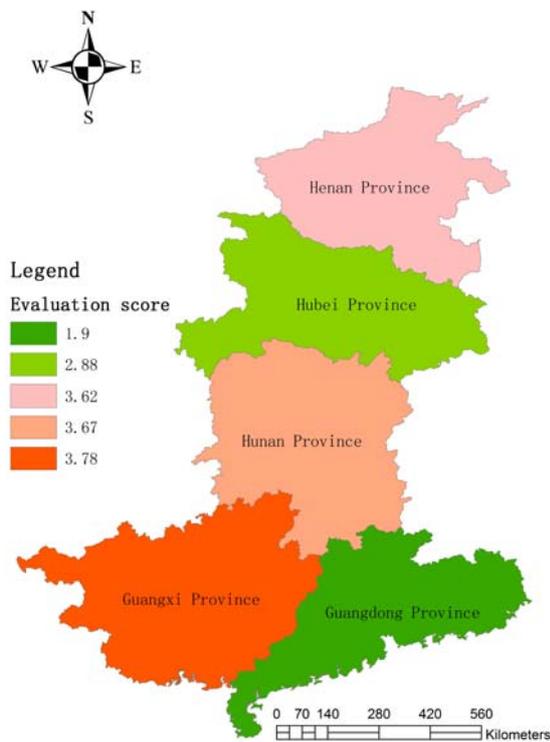

Figure 2. Distribution map of financial ecological environment evaluation score for the STSMEs in five provinces of South Central China

GIS is a technological system integrating collection, storage, management, operation, analysis, display and description for spatial geographic distribution data. The evaluation result can be calculated quickly and shown visually by GIS. In this paper, GIS is used to display the evaluation results . In GIS figure, different grades of region on the map with different colors, for example, green means excellent grade, red represents good grade(Fig. (2)). It favors investor and decision-maker to further analyze the evaluation results by the color classification with GIS.

C. Analysis of evaluation results

According to the index system and model above, the financial environment evaluation grade on five provinces in turn (from excellent to very poor) is Guangdong, Hubei, Henan, Hunan, Guangxi. In general, the evaluation results of five provinces are all above the grade of good, which suggests the financial ecological environments in five provinces are conducive to the survival and development of the above enterprises.

In particular, Guangdong and Hubei in excellent grade, which have unique advantages in scientific and technological environment closely related with their national strategic position and technological industry orientation. Both the two provinces are the cores of the two Chinese urban agglomerations of Pearl River Delta and Yangtze River middle reaches in China, and also the demonstration areas for national industrial upgrading and innovation driven. Guangdong Province is far ahead of the other provinces in the financial environment, especially the indirect financial environment, related to its rapid economic growth and accumulation, the financial market developing and the active financial innovation.

Outside dividing Guangdong, the outstanding problem of other four provinces facing is the financial channel single, over reliance on bank finance, and the use of the multi-level capital market not enough. How to dig the financial resource from the capital market, which has the huge financial ability, should be the question which the each province needs to face and solve in the future.

V. CONCLUSIONS

The financial ecological environment of scientific and technological small-medium enterprises, which is affected by a lot of different factors, is very important for their developments. In this paper, we adopt AHP method to construct an index system and establish a corresponding evaluation model for financial ecological environment of scientific and technological small-medium enterprises. The case study of the five provinces in south central China shows that the AHP approach proposed in this paper is very effective and visual to evaluate the financial ecological environment of scientific and technological small-medium enterprises. It is accurate and intuitive to understand the

survival and developing environment of the enterprises, and convenient for in-depth analysis on one certain financial ecological environmental indicator, which is not only very helpful for investors to make correct judgment, but also useful for government to formulate relevant policies.

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