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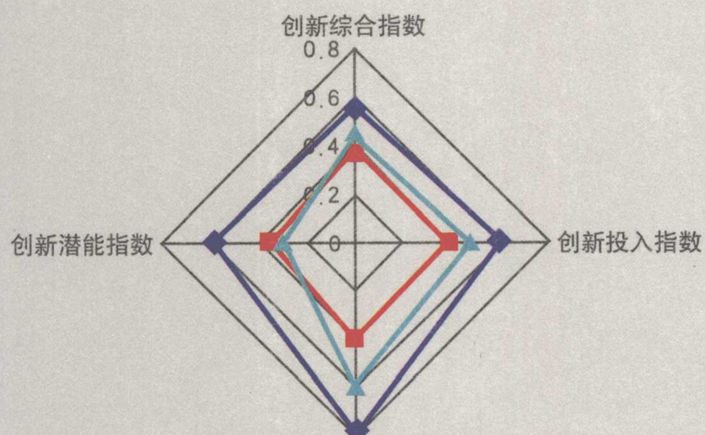
Development Research Center CAST/Serial Reports on Strategic Research

国家创新能力评价报告

Evaluation Report on National Innovation Capacity

中国科协发展研究中心
国家创新能力评价研究课题组



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序

当今时代，人类社会步入了一个科技创新不断涌现的重要时期，国民财富的增长和人类生活的改善越来越依赖于知识的积累和创新。谁在知识和科技创新方面占据优势，谁就能够在发展上掌握主动。自主创新是发展科学技术的战略支点，因此必须高度重视技术创新特别是自主创新在经济社会发展中的决定性力量，认识到自主创新是国家自强之本，积极推进国家创新体系建设，使中国进入创新型国家行列。这不仅是中国落实科学发展观、转变经济增长方式的必然要求，而且是中国适应国际经济形势、提高国际竞争力的重要举措。如果不增强自主创新能力，中国的资源、能源将难以支撑，生态环境将难以为继，国家竞争力将难以提高，国家安全将难以保障。

近些年来，国家创新能力研究取得了长足进步，尤其表现在如何建立和优化国家创新体系，使各创新主体发挥最佳作用，形成合力，促进国家创新能力的提升。在这方面，学界取得了一定的共识，即建设以企业为主体、产学研结合的技术创新体系，建设以高等院校、科研院所为主体的知识创新体系，建设和完善包括中介组织、知识产权保护、发展创新文化在内的科技创新支撑、服务与培养体系等。

与此同时，国家创新能力测评研究越来越受到学术界和各国政府及国际组织的重视，出现了一些极具影响力的测评体系，如经济合作与发展组织（Organisation for Economic Co-operation and Development，OECD）的“科学、技术和产业记分板”，欧盟的“欧洲创新记分板”、“全球创新记分板”等，为各国了解本国创新现状及与他国创新能力的差距、有针对性地进行创新政策的调整提供了重要的参考。目前，很多测评体系都有进一步深化研究的必要，特别是深化研究创新绩效和创新能力的区别。事实上，创新绩效测评强调的是一国在某个时间点创新活动的水平，或者说反映的是创新存量；创新能力测评强调的不仅仅是测量一国现有的创新水平，更强调创新的结构方式、效率和潜能，更强调长期性。创新能力测评研究显得尤为重要。

本报告建构了一个由创新投入、创新产出、创新潜能和效率 3 大类（7 个维度、21 个指标）组成的国家创新能力评价指标体系。与其他测评体系相比，这个框架的特色是将创新潜能和效率作为国家创新能力中至关重要的因素，注重创新能力发展的长期性、战略性和潜在性。不求一时之胜，但求持续发展。就国家科技政策尤其是科技发展战略调整而言，这一框架所揭示出来的创新能力发展现状具有启发意义。

当前，建设创新型国家已成为许多国家尤其是发达国家提高综合国力的基本国策。就中国而言，建设创新型国家更是应对时代挑战、全面建设小康社会、实现中华民族伟大复兴的必由之路。2006 年初，胡锦涛总书记在全国科学技术大会上指出，到 2020 年要把我国建设成为创新型国家，使科技发展成为经济社会发展的有力支撑。2007 年，党的十七大报告明确将提高自主创新能力、建设创新型国家列入国家发展战略的核心。

通过建立国家创新能力指标体系，对国家创新能力进行测度，既可以了解世界各国创新发展的水平，从中汲取经验和教训，又能监测本国创新发展的现状，及时掌握创新政策的偏差，对政府调整、改进创新政策大有裨益。

中国科协发展研究中心主任李士研究员，长期从事科技政策研究，对科技政策发展走向有着高度的敏感性。《国家创新能力评价报告》是具有前瞻性、预测性的重要课题。《国家创新能力评价报告》课题组能够在短时期内取得这样的成果，我表示由衷的祝贺。同时，希望中国科协发展研究中心的国家创新能力评价研究工作能持续做下去，针对新情况，研究新问题，取得新成果，不断为政府决策提供有益的参考。

遵嘱，是为序。

冯之浚

2009年5月21日

Abstract

Development of knowledge-based economy and S&T innovation in the 21st century promotes the flourishing of studies in the domains of national innovation capacity evaluation, by experts and scholars from various countries and international organizations such as OECD and EU. In 2000, EU released *Innovation in a Knowledge-driven Economy*, and from then on a series of annual reports of EIS were released. In 2004, the United States Council on Competitiveness published *Innovation America.* And in 1999, OECD modified STI and introduced new indicators aiming to evaluate innovation performance. Basically, these indicators focus on resources distribution in various parts of innovation system based on cost and short-term payoff, but fail to consider specifically the critical elements of innovation potential, such as innovation strategy reserves, innovation input trend and innovation efficiency. Especially in the period of worldwide finance crisis, innovation potential and innovation efficiency should be highlighted in evaluating national innovation capacity.

Since 2006, Project Team for Evaluation on Development of National Innovation Capacity in Development Research Center of China Association for Science and Technology (CAST) has developed theories and evaluation indicator system on national innovation capacity, consisting of innovation input, output and potential. A comparative study is completed on national innovation capacity and innovation policies of 34 countries, i. e. U. S. A., Japan, EU members, and the BRIC countries (Brazil, Russia, India and China). The study aims to explain the differences in the countries' innovation capacity, distinguish blocks to development for policy-makers and enterprise leaders to be aware of the blocks hindering the development, and help them to upgrade policy-decision and system modification abilities. The study on national innovation capacity reflects both the international appeal and economic development direction of China.

Chapter I National Innovation Capacity Evaluation Indicator System

This chapter introduces the theoretical foundations of the national innovation capacity evaluation indicator system, which consists of three key factors, namely innovation input, innovation output and innovation potential. Innovation potential is considered crucial in measuring the innovation capacity, which is of persisting and strategic significance, because innovation potential illustrates an innovation system's long- and medium-term sustainable development capacity. Instead of using a resources distribution model based on cost and short-

term payoff, evaluation of national innovation capacity should reflect on potential of the innovation system that can produce values in a sustainable way. In our system, national innovation capacity is comprised of two parts, namely current innovation status (input and output) and innovation potential. Innovation input includes material capital, S&T human resources, and policy environment. Meanwhile innovation output consists of intellectual property rights and application performance. Innovation potential contains strategy reserves and innovation development trend.

Differences between current status of innovation and innovation potential lie in the fact that the former one presents the static capacity, demonstrated by annual input and output state; while the latter illustrates the dynamic foresight of development, including infrastructure and development trend of innovation system, which sheds its influence on innovation capacity through impact on innovation input, output and efficiency. Core of our evaluation system is the focus on innovation potential and its persistent and strategic value. Based on this concept, 21 indicators are designed in our national innovation capacity indicator system (Table 1).

Table 1 National innovation capacity indicator system

Key factors	Dimensions	Indicators
1. Innovation input	1. 1 Material capital	1. 1. 1 GBAORD as a percentage of GDP (%)
		1. 1. 2 Business enterprise expenditure on R&D as a percentage of GDP (%)
		1. 1. 3 The ratio of early venture capital as a percentage of GDP (%)
		1. 1. 4 The ratio of FDI inflows as a percentage of GDP (%)
1. Innovation input	1. 2 S&T human resources	1. 2. 1 Human resources in science and technology as a percentage of total employment (%)
		1. 2. 2 Science and Engineering graduates as a percentage of total tertiary-level graduates (%)
		1. 2. 3 R&D personnel per thousand total employment (person)
	1. 3 Policy environment	1. 3. 1 Tax treatment of R&D (%)
		1. 3. 2 Its regime for the protection of intellectual property rights
		1. 3. 3 The strength of its antitrust law
2. Innovation output	2. 1 Intellectual property rights	2. 1. 1 Triadic patent families per million population
		2. 1. 2 Science & Engineering articles per million population
		2. 1. 3 Patent intensity (patent number/business enterprise expenditure on R&D)
	2. 2 Application performance	2. 2. 1 Share of high-tech activities in manufacturing value added (%)
		2. 2. 2 High technology exports of manufactured exports (%)

Continued

Key factors	Dimensions	Indicators
3. Innovation potential	3. 1 Strategy reserves	3. 1. 1 The ratio of expenditure for higher education as a percentage of GDP (%)
		3. 1. 2 Trade openness ratio (%)
		3. 1. 3 ICT expenditures as a percentage of GDP (%)
	3. 2 Development trend	3. 2. 1 The average annual growth rate of Government budget appropriations or outlays on R&D (past five years) (%)
		3. 2. 2 The average annual growth rate of the business inputs on R&D (past five years) (%)
		3. 2. 3 The average annual growth rate of R&D personnel (past five years) (%)

Chapter II Results and Analysis of National Innovation Capacity Evaluation

This chapter presents the results of national innovation capacity evaluation of 34 countries in terms of aggregative indicator (Figure 1), three key factors (Figures 2-4), 21 indicators, based on data selected from 2005 to 2006. Besides, features of each country's innovation capacity structure and ranking are also listed in this part.

Two ways of cluster analysis are adopted, based on aggregative indicator and three key evaluation factors respectively, to categorize various countries according to their innovation capacity.

Moreover, this chapter also explores the relationship between the aggregative indicator and three key factors, and constructs an innovation capacity aggregative indicator model based on Multiple Linear Regression Analysis.

2. 1 Ranking of 34 Countries

2. 1. 1 Aggregative Indicator

The top five countries measured by aggregative indicator are: U. S. A. (0. 565), Sweden (0. 542), Finland (0. 538), ROK (0. 528), and Switzerland (0. 526). The countries that perform the least in the aggregative indicator are Russia (0. 121), Poland (0. 190) and Slovak (0. 191). China gains 0. 332 in this indicator, which ranks 23rd in all 34 countries. Mean value of this indicator for all 34 countries is 0. 379, while that of OECD 30 member countries is 0. 398.

2. 1. 2 Innovation Input

The top five countries measured by innovation input indicators are: U. S. A. (0. 597),

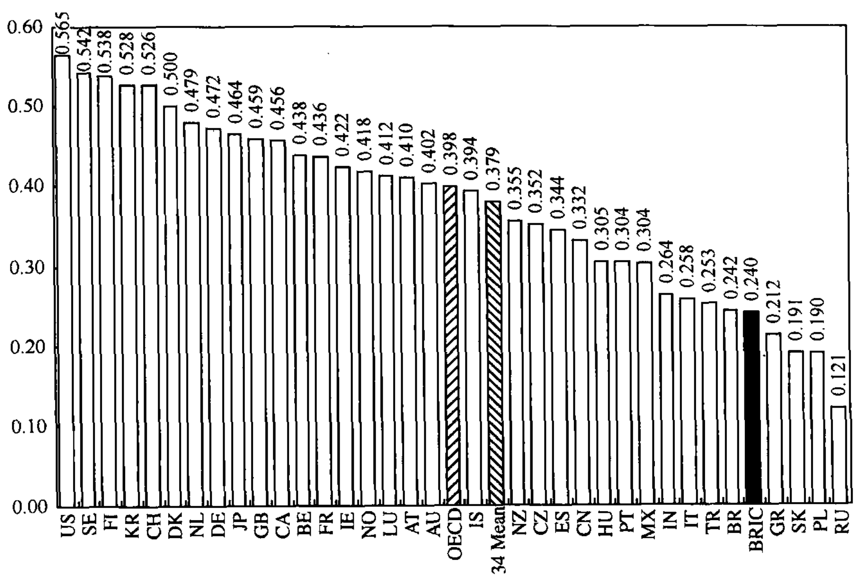

Figure 1 Ranking of aggregative indicator

Finland (0. 593), Sweden (0. 585), Denmark (0. 533) and Canada (0. 520). The countries that perform the least in the innovation input indicators are Turkey (0. 155), Russia (0. 163) and Poland (0. 180). China gains 0. 290 in these indicators, which ranks 24th in all the 34 countries. Mean value of these indicators for all 34 countries is 0. 388, while that of OECD 30 member countries is 0. 407.

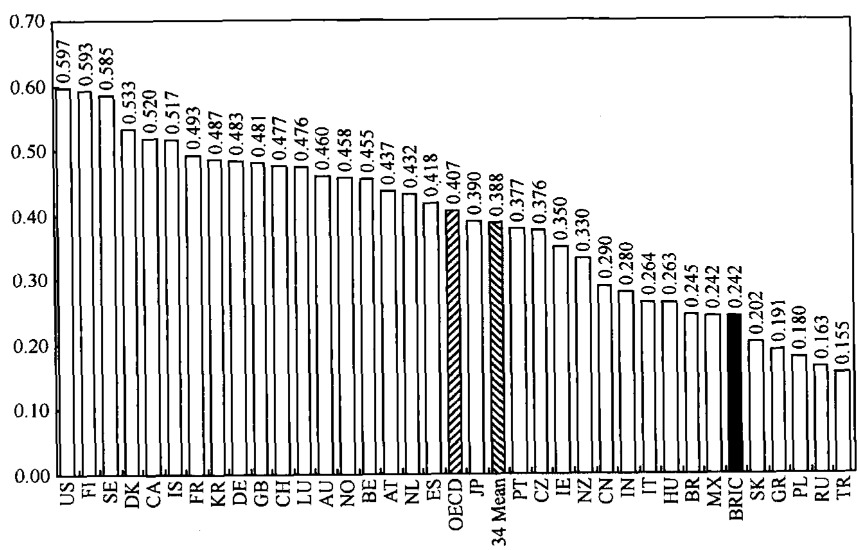

Figure 2 Ranking of innovation input

2.1.3 Innovation Output

The top five countries measured by innovation output indicators are: Switzerland (0.793), Japan (0.789), the Netherlands (0.718), ROK (0.709) and Germany (0.692). The countries that perform the least in the innovation output indicators are Turkey (0.104), Russia (0.111) and Poland (0.121). China gains 0.290 in these indicators, which ranks 20th in all 34 countries. Mean value of these output indicators for all 34 countries is 0.410, while that of OECD 30 member countries is 0.437.

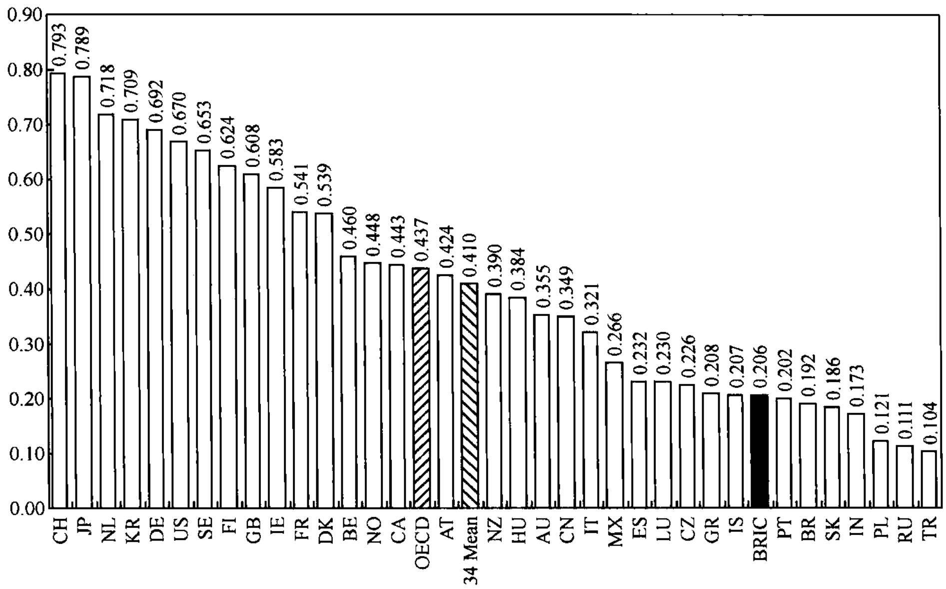

Figure 3 Ranking of innovation output

2.1.4 Innovation Potential

The top five countries measured by innovation potential indicators are: Turkey (0.579), Luxemburg (0.455), ROK (0.444), Mexico (0.437) and U. S. A. (0.424). The countries that perform the least in the innovation potential indicators are Russia (0.059), Slovak (0.176) and Italy (0.197). China gains 0.342 in these indicators, which ranks 10th in all 32 countries. Mean value of these potential indicators for all 34 countries is 0.342, while that of OECD 30 member countries is 0.350.

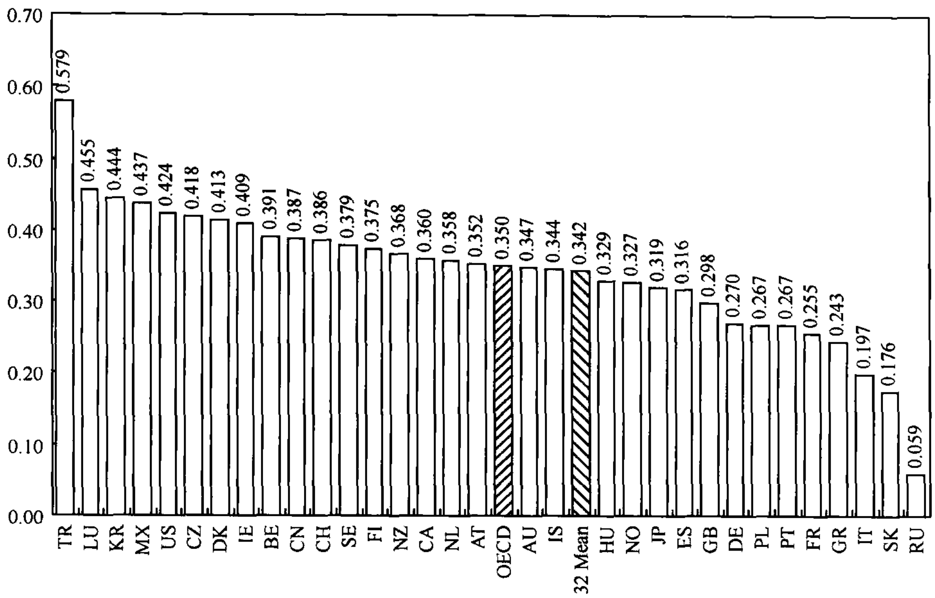

Figure 4 Ranking of innovation potential

The ranking doesn't contain Brazil and India for lack of data and failure of regression

2.2 Cluster Analysis

Hierarchical clustering techniques based on between-groups linkage (through squared Euclidean distances) are adopted to categorize the 34 countries into 5 groups according to their innovation capacity, as illustrated in the following table (Table 2).

Table 2 Clustering of 34 countries based on aggregative indicator (2006)

Clusters	Countries	Total	Mean value
Cluster 1: Very high level	U. S. A., Sweden, Finland, ROK, Switzerland	5	0. 540
Cluster 2: High level	Denmark, the Netherlands, Germany, Japan, Britain, Canada, Belgium, France, Ireland, Norway, Luxemburg, Austria, Australia, Iceland	14	0. 440
Cluster 3: Medium level	New Zealand, the Czech Republic, Spain, China, Hungary, Portugal, Mexico	7	0. 328
Cluster 4: Low level	India, Italy, Turkey, Brazil, Greece, Slovak, Poland	7	0. 230
Cluster 5: Very low level	Russia	1	0. 121

Chapter III Comparative Analysis on Development of Innovation Capacity of Typical Countries

In order to manifest different development modes of innovation capacity with particular characteristics, some typical countries and regions such as the BRIC countries, the European Union, the United States, Japan and ROK, are selected to carry out empirical research. On the basis of analysis on history of policies, basic situation and features of their innovation capacities, the team made a contrast of those innovation systems of different countries and regions.

3.1 Comparative Analysis on Development of Innovation Capacities among the BRIC Countries

It is believed that BRIC countries (Brazil, Russia, India and China) are representatives of newly emerging countries with potentials. Our research mainly includes the following:

1. After reviewing the history, structure, strategy and policy of innovation systems of the BRIC countries, the team found that four countries recognize the importance of development of science innovation system in the early period. Accordingly, they have been providing support for innovation activities in terms of policy and fund so as to improve innovation system and environment.

2. Similarities among BRIC counties mainly consist of:

(1) transformation from government-oriented mode to multi-polar mode with the function of several innovation main players;

(2) increasing emphasis on the construction of innovative country as well as the function of innovation on economic development.

3. Among the 34 countries included in this evaluation, BRIC countries are among the lagging countries on overall innovation capacities. There is a tremendous gap between the average BRIC countries' value (0.240) and that of OECD members. Four countries rank 23rd (China), 27th (India), 30th (Brazil) and 34th (Russia) respectively.

3.2 Comparative Analysis on Development of Innovation Capacities of EU

EU's innovation system is a cross-country regional system. Its development has experienced a coordination process full of twists and turns. Our research mainly includes the following:

1. Based on review of the history of innovation system of EU (from the European miracle to the European paradox), it is pointed out that the greatest challenge of the enhancement of EU's innovation capacity lies in the poor ability to transfer the result of technological research to

innovation and competitive advantage.

2. The team has made a detailed analysis on the history of EU's innovation policies and roadmaps. In 1952, initial cooperation between the European Coal and Steel Community started. Later, the European Community was established in 1967. In a real sense, the innovation policy at European level appeared since the EU treaty took effect in 1993. Since the end of the Second World War, the policy makers of Europe have implemented and enforced seven detailed R&D plans of high investment with wide areas, which played an important role during the implementation of innovation strategy of the European Union.

3. It is found out that diversity and similarity are in existence simultaneously in the cross-country innovation system of EU. Although there are some problems, such as insufficient input on R&D and slow transfer of innovation results, EU's overall innovation capacity is rising gradually as a result of continuous coordination of innovation policies and mutual efforts of member countries. Accordingly, the gap between EU's innovation capacity and that of America and Japan is getting narrow.

3.3 Comparative Analysis on Development of Innovation Capacities of America

In the past few decades, American economy and innovation capacity have been taking the lead in the world. As a typical representative of developed countries, it possesses a market economic system of highest openness with sound foundation. The research mainly includes the following:

1. As a leading country in terms of R&D input and innovation talents, America owns special entrepreneurship culture and policy environment , which lays a solid foundation for innovation capacity.

2. Under the new background of knowledge economy and globalization, adjustment of American innovation strategy consists of :

(1) Emphasis on scientific service;

(2) Emphasis on important areas and links of innovation;

(3) Emphasis on cultivation of talents and improvement of vision on education and training;

(4) Enhancement of support for the innovation enterprises in terms of policy at the state level.

3.4 Comparative Analysis on Development of Innovation Capacities between Japan and ROK

It is of significance to review the history of innovation system of Japan and ROK as well as their ways taken to improve innovation capacities so as to summarize innovation development mode of Asian countries, for both of them are world economic powerhouses. Our research mainly includes the following:

1. All in all, Japanese innovation input and potential are at the middle level among the 34 countries evaluated, while innovation output ranks second, which is very impressive. The performance of ROK is very good both on innovation input and output, with potential taking the 3rd place.

2. Their similarities lie in the following facts:

(1) The government plays a leading role;

(2) Cooperation among industry-university-research is attached importance to;

(3) They both borrowed western technology first, and then made corresponding adjustments.

(4) Enterprises are main players of innovation.

3. Difference among Japanese and ROK innovation mode and American mode mainly exist in the following facts:

(1) Governments in Japan, ROK and the U. S. work in different ways. As for the former two (government-oriented mode), governments are involved in innovation activities. However, in the latter case (government-assisted mode), government rarely promulgates laws on innovation policy. It only makes limited policies with an aim to create a good environment.

(2) Innovation in Japan, ROK and the U. S. develops with different emphasis. In Japan and ROK, application in industry leads to scientific research while basic research gives rise to progress in industrial technology in the U. S. Compared with the latter, the former two lay particular emphasis on innovation in process gradually, with an intention to decrease industrial cost.

Chapter IV International Comparison of Development of China's National Innovation Capacity

In this chapter, international comparison of present situation and prospects of China's innovation capacity has been made in the terms of input, output and potential. Based on calculation of innovation efficiency of 34 countries, the team has analyzed the rankings of China's innovation capacity and made a contrast of efficiency gaps among different systems.

4.1 Comparative Analysis on China's Innovation Input

In a comprehensive way, China's innovation input is lower than average of OECD member countries, lagging far behind the U. S. A., Japan and ROK. In the three dimensions of input, the biggest gap exists in the aspect of material capital.

In terms of S&T human resources, China's input is getting close to OECD average, above the average of Japan and ROK, with a smaller gap to American input. As for input in policy environment, China is behind the U. S. A., with a narrow gap between average of Japan, ROK and OECD member countries. Among the BRIC countries, China ranks first in terms of overall input and three dimensions.

4.2 Comparative Analysis on China's Innovation Output

The score of China's capacity on innovation output is lower than that of OECD member countries, lagging far behind Switzerland, the Netherlands, Japan, ROK and other countries. In the three dimensions of output, although it ranks first in the BRIC countries, China still falls far behind Switzerland, Japan, ROK and America in terms of technology innovation, with a big gap from the average of OECD member countries.

As to knowledge innovation, China's score is lower than average of not only OECD member countries but also the BRIC countries. However it is higher than those in terms of economic output.

4.3 Comparative Analysis on China's Innovation Potential

The following chart displays structure of international comparison of some key elements of China's innovation potential (Figure 5).

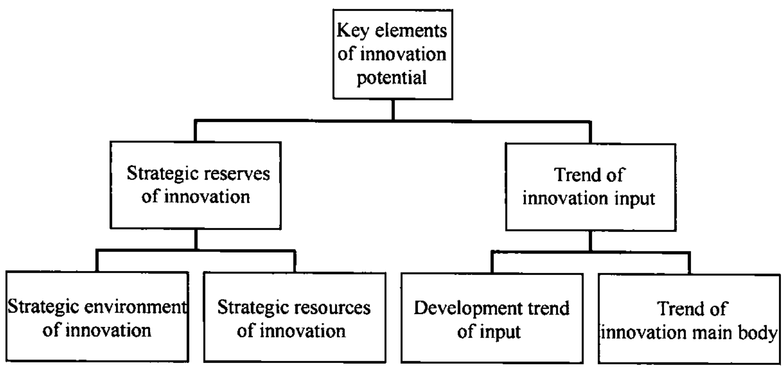

Figure 5 Structure of international comparison of key elements of China's innovation potential

4.3.1 Innovation Reserves

Innovation strategic environment refers to overall development environment for a country to carry out innovation activities and make specific choices on innovation strategy. At present, China's total economic output has risen to the 4th place in the world. The total trade volume has climbed to the 3rd, accounting for 7.7% of the world trade volume, only less than the U. S. A. and Germany.

Innovation strategic reserves refer to those possessing strategic value for innovation development. At present, China is rich in S&T talents and the number is growing fast. Basic ICT infrastructure network has been set up, connecting every part of China with the world.

4. 3. 2 Trend of Innovation Input

For those leading innovative countries, their innovation input is very high and it tends to rise year by year. In addition, they attach importance to its strategic rationality.

In recent years, China has been increasing its input at an annual rate of 21. 7% during five years (2002 ~ 2006) on average , much higher than 5. 5% in the U. S. A. Nevertheless, in contrast with rapid development of science and technology, there is still much room of overall volume and intensity. In 2005, China's R&D input accounts for 1. 34% of GDP, while the percentage is 2. 67% in the U. S. A. and 3. 17% in Japan during the same period, which reflects interim gap between China and other developed countries in this respect.

All kinds of relations of main bodies have composed multi-polar innovation network. From advanced countries' experience, we can see all of them intensity the leading role that enterprises play in the network.

As far as Chinese enterprise R&D input is concerned, its annual increasing rate is 26. 43% (2002 ~ 2006) on average, much higher than those in Japan, America and ROK. Judging annual increasing rate of China's government and enterprise R&D input, we can arrive at the conclusion that they both attach more and more importance to R&D and the position of enterprise as a leading payer has been established further.

4. 4 Comparative Analysis on China's Innovation Efficiency

In this chapter, DEA (Data Envelopment Analysis) has been used to analyze 34 countries in order to make a contrast of efficiency among different innovation systems, with input indicator of national innovation capacity development index as input dimension, together with output indicator as output dimension.

Suppose returns to scale stay still, hopefully fixed input would result in better output performance. Thus, output-oriented DEA method has been employed. MAT LAB, a mathematics analytical and calculation software, is used to design corresponding DEA computer program to calculate innovation efficiency of 34 countries. The following table (Table 3) shows the final analytical DEA result.

Table 3 Analytical result of composite index

Number	Country	Efficiency	Ranking	Times as benchmark
1	China	1	5	6
2	Brazil	0. 9707	21	0
3	Russian Federation	1	14	1
4	India	0. 8943	25	0
5	Australia	0. 8592	27	0