

A POSITIVE ANALYSIS ON THE PERFORMANCE OF NATIONAL S&T PROGRAMS: FROM THE PERSPECTIVES OF INPUTS AND OUTPUTS

Lu Cui^a, Shuhua Zhong^b

^{a, b} College of Public Administration, Huazhong University of Science and Technology,
Luoyu Road, Hongshan district, Wuhan, China.

^a Corresponding author: cui136138@qq.com

©Ontario International Development Agency ISSN: 1923-6654 (print)

ISSN 1923-6662 (online). Available at <http://www.ssrn.com/link/OIDA-Intl-Journal-Sustainable-Dev.html>

Abstract: In China, the National S&T Programs (NSTP) include the National Natural Science Foundation (NNSF), the National Key Technologies R&D Program, National High Technology Research and Development Program (the National 863 Program), and the National Basic Research Program (the National 973 Program). During 2001-2009, the investment of NSTP kept increasing. And in its funded programs, the amount of published papers and patent were also increasing year by year. In detail, the fund of investment in NNSF kept increasing with an average annual growth rate of 19%. The amount of published papers in international journals in those funded programs kept increasing with an annual average growth rate of 17.55%. The National Key Technologies R&D Program has gained 25.483 billion yuan total finance allocations; During 2002-2009, the amount of published papers in international journals has summed up to 20,617, the foreign patent applications have reached 897 and the foreign patent authorizations have hit 189. The National 863 Program gained 33.872 billion yuan total finance allocations, a 14.8% average annual growth rate; in its funded projects, the number of published papers in international journals has totaled 66,612, and the foreign patent applications were 2,166, 497 of which gained the foreign patent authorization during 2002-2009. As to the National 973 Program, the total finance allocations added up to 11.483 billion yuan, a 20.12% annual average growth rate; from 2002 to 2009, the number of published papers in international journals in National 973 Program

funded projects has reached 97,323, and in the 459 foreign patent applications, 133 of them have been authorized.

Keywords: China; National Natural Science Foundation; National Key Technologies R&D Program; National 863 Program; National 973 Program; National Key Technologies

INTRODUCTION

In China, the National Science and Technology Programs (NSTP) framed by the central government bears the weight of national science and technology policy, including the strategic goals, plans and measures of the national science and technology development. The NSTP (including National Natural Science Foundation, the National Key Technologies R&D Program, National 863 Program and National 973 Program) is so far the highest level of science and technology program with the biggest investment and the largest scale. It represents the policy arrangement of pooling resources to achieve big goals in the field of science and technology in China. In the new period of constructing a creative China, the national science and technology program leads the direction, path and seed of China science and technology.

The input of NSTP belongs to the central government expenditure. Every year the investment is allocated to natural science foundation of China and the Ministry of science and technology according to the financial budget. During 2001-2009, the central finance allocations for science and technology amounted

805.21 billion yuan. Among those financial allocations, the NSTP gained 100.466 billion yuan, taking up 12.48% of the total amount. This rate remained stable around 11.66% during 2001-2009. The achievements of the NSTP were great. During 2002-2009, the number of published papers in international journals increased year by year with a total of 369,104. This amount occupied 58.8% of included papers by Chinese science and technology researchers in SCI and EI, two main retrieval tolls abroad. The number of foreign patent authorizations amounted to 819 in the National Supporting Plan, National 863 Program and National 973 Program.

The NSTP plays a crucial supporting role in exploiting the leading function of technology in economic and social development. We can extract information about the NSTP executive efficiency and effect through an empirical analysis on the input and output of NSTP. The empirical analysis can also provide decisive consultation for the NSTP improvement.

MATERIALS AND METHODS

The Analysis on the Input and Output of the National Natural Science and Technology Foundation

The National Natural Science Foundation supports basic research and encourages knowledge innovation. It has achieved great success in promoting the development of basic research of Chinese natural science as well as exploring and cultivating outstanding talents in science and technology. The useful explorations in enhancing the innovative capacity of basic research have accumulated valuable experiences. It has made positive contribution for the development of Chinese basic research and the overall research level. Fig.1 shows the input of finance allocations in National Natural Science Foundation during 2001-2009.

We can see the central finance allocations for the National Natural Science Foundation presents an obvious growth trend during 2001-2009. In 2009, the finance allocation is 6.427 billion yuan, four times larger than that in 2001. In the meantime, there are fluctuations of the rate of finance allocations for National Natural Science Foundation in the overall finance allocations in science and technology programs. Linear regression analysis reveals that the regression line of the points on the curves is the 30% line in the coordinate. In other words, the rate fluctuates around 30%. The amplitude is relatively stable with a maximum of 33.58% and a minimum of 26.9%.

The output of general program .General program is the main part in the National Natural Science

Foundation system. It includes three sub-types: free application, National Science Foundation for the Youth and Regional Science Foundation. We choose the number of reports in international conferences, published papers in international journals and the international awards to analysis the achievement in general program.

During 2001-2009, the National Natural Science Foundation funded programs have been invited by many international conferences and the reports they have issued in those conferences surged from 5,487 to 12,729 with a more than one time growth. In 2009, the number of published papers in international journals reaches 28,243, 3.89 times larger than that in 2001. From 2002-2009, the number of published papers in oursea journals in general programs takes up 22.43% of all the papers by Chinese science and technology researchers included in SCI and EI. Furthermore, the amount of international awards is also increasing.

The output of general program. The key program of National Natural Science Foundation supports the science and technology staff to hold the frontiers of world science to carry out deep, systematic and creative researches in key research fields or new disciplines. Those researches should be carried out according to the national needs and based on existing foundation and accumulation. Table 2 shows the achievement in key program.

The achievement of key program shows a rapid growth. In the nine years, the number of its published reports in international conferences displays a 1.84 times growth, reaching 2,267 in 2009. The amount of published papers in international journals in 2009 is 4.79 more than that in 2001. The number of international awards presents a growth trend. In 2008, they gains 34 international awards.

The output of major program. The funded fields in major program cover four parts. The first part is advanced basic research which reaches or approaches advanced internal level with strategic significance. The research should also be competitive for China, and is expected to obtain major breakthrough. The second part is urgent key scientific problem and basic research which is influential or promising for exploring the development of high-tech industry. The third part is basic key research which is about the national strategy aim for sustainable development or can provide foundation for national macro decisions. This part also includes basic work such as data accumulation which can be influential in the future. The fourth part is the accumulating key scientific problem which is considered to increase the funding in order to obtain the expected major breakthrough in general and key programs. [1]

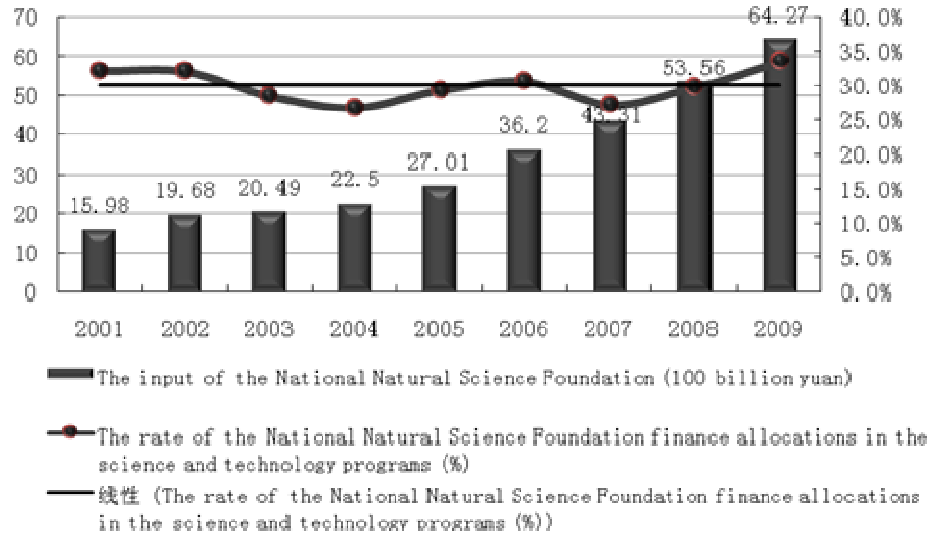


Figure1: The Input of Finance Allocations in National Natural Science Foundation During 2001-2009

Source: State Statistics Bureau, the Ministry of Science and Technology, *China Statistical Yearbook on science and technology* (2002-2010); Committee of the National Natural Science Foundation, *Annual Report* (2001-2010), Website of Committee of the National Natural Science Foundation <http://www.nsf.gov.cn/Portal0/default124.htm>

Table 1: The Statistics of General Program Achievement in the National Natural Science Foundation

	No. of reports in international conference	No. of published papers in international journals	No. of international awards
2001	5487	7262	53
2002	3259	5747	13
2003	5893	11418	51
2004	7376	13610	62
2005	7735	16470	80
2006	8866	20121	64
2007	10016.5*	21284*	79*
2008	11167	22447	95
2009	12729	28243	132

Source: Committee of the National Natural Science Foundation. *Annual Report* (2001-2010)

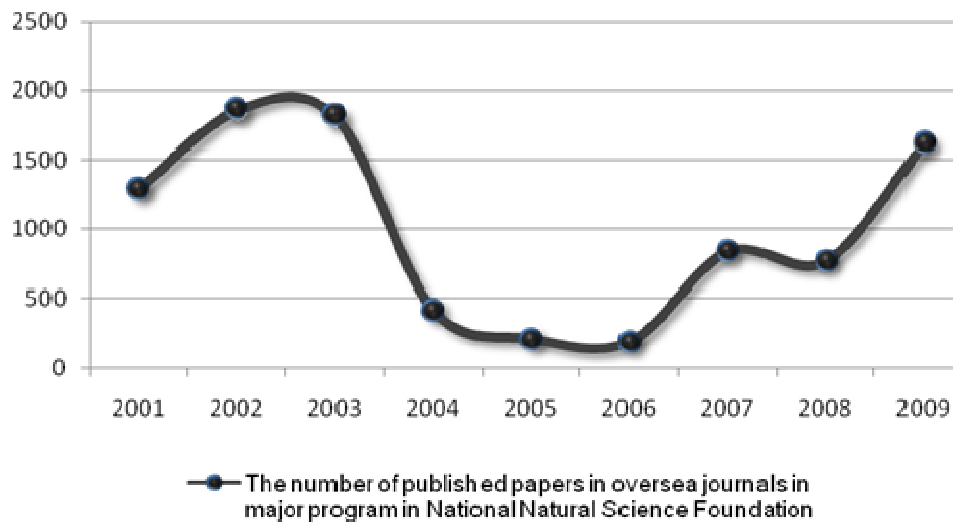
Website: <http://www.nsf.gov.cn/Portal0/default124.htm>

* The results of 2007 are the average of 2006 and 2008

Table 2: The Statistics of Key Program Achievement in The National Natural Science Foundation

	No. of reports in international conferences	No. of published papers international journals	No. of international awards
2001	799	1155	8
2002	988	1817	8
2003	807	1773	13
2004	1183	2338	10
2005	457	1031	5
2006	558	2824	25
2007	1231	3289	19
2008	2361	6936	34
2009	2267	5528	18

Source: Committee of the National Natural Science Foundation. *Annual Report (2001-2010)*
 Website: <http://www.nsf.gov.cn/Portal0/default124.htm>

**Figure 2:** The Number of Published Papers In International Journals In Major Program In National Natural Science Foundation during 2001-2009.

Source: Committee of the National Natural Science Foundation. *Annual Report (2001-2010)*
 Website: <http://www.nsf.gov.cn/Portal0/default124.htm>

During 2001-2009, the major program has published 9,018 papers in international journals and gained 17 international awards. The number of published papers in international papers displays an inverted parabola shape. It begins to increase after reaching the lowest point in 2005.

The input and output of the National Key Technologies R&D Program

The National Key Technologies R&D Program was founded in 2006 on the base of the National Leading Science and Technology Program. It includes basic and application research and aims at solving key problems in the construction of national economy. This program emphasizes on exploration and demonstration of important public technology and industrial generic researches. It plays a crucial role in improving the national independent innovation ability, performing the supporting function of technology in the national economy development and accelerating the construction of an innovative country. Fig. 3 shows the input of finance allocations in National Key Technologies R&D Program during 2001-2009.

During 2001-2009, the finance allocations in National Key Technologies and R&D Program keep increasing and the total amount in the nine years reached 25.483 billion yuan. In 2009, the total input is 5 billion yuan, 3.7 times larger than that in 2001. The rate of National Key Technologies and R&D Program finance allocations in the national central finance allocations keep increasing. In 2001-2005, this rate is stable around 25%. In 2006-2007, this rate grows rapidly, taking up 47% of the overall finance allocations.

A comparative analysis on the input of various fields in National Key Technologies and R&D Program .The National Key Technologies and R&D Program arranges in 11 fields, including energy, resources, environment, agriculture, manufacture, materials, transportation, information industry and modern service industry, population and health, urbanization and urban development and public security. Due to the limited data access, we will use the classification before 2006 by the State Statistics Bureau and the Ministry of Science and Technology. According to this classification, we will analyze the 8 key supported fields in the National Key Technologies and R&D Program. During 2001-2009, the finance allocations among the 8 fields display a growth trend. However, their rates in the National Key Technologies and R&D Program change a lot (see table 3).

In general, agriculture and public security take up a relatively larger amount. The highest rate for agriculture is 26.29% (780 million yuan) with an

average fluctuation around 20%. Public security reached the highest rate point of 24.05%. But its rate in the overall program is a decline trend. There is a fluctuation in the field of population and health with the highest point of 24.91% and the lowest point of 7.67%. The rates of material, manufacture and information industry are relatively low with a frequent fluctuation. The rates of energy and resource are increasing with an obvious growth trend.

Analysis on the output of the National Key Technologies and R&D Program. The National Key Technologies and R&D Program attained great achievement in the field of energy, resources, environment, agriculture, manufacture, materials, transportation, information industry and modern service industry, population and health, urbanization and urban development and public security. During 2002-2009, the number of published papers in international journals in its funded projects keeps increasing. In 2009, the total number hits 6, 668, 11.4 times larger than that in 2002. The largest growth rate occurs in 2008 when the number is almost 3,000 more than that in 2007. According to statistics, the National Key Technologies and R&D Program has published 20,617 papers in international journals. Fig.4 gives detailed information.

The National Key Technologies and R&D Program emphasizes the ability of independent innovation through the program. It aims at mastering core technology and enhancing the ability of independent innovation. It encourages original innovation, integrated innovation and re-innovation of the introduced technology. Thus, one of the National Key Technologies and R&D Program goals is to obtain achievements with Independent intellectual property rights. Table 4 shows the number of foreign patent application and authorization in the National Key Technologies and R&D Program funded projects during 2002-2009.

During 2002-2009, the National Key Technologies and R&D Program has applied 897 foreign patents and 189 of them have been authorized by foreign patent. In 2008, the number of foreign patent application is 123 of which 69 have been authorized, taking up 56.1% of the overall applications. In 2009, the number of foreign patent application was 199 of which 38 have been authorized. Furthermore, the number in 2006 is 9 and in 2007 it is 37, which are relatively less than other years.

The Input and Output of the National High-Tech Research and Development Program (The National 863 Program)

The National 863 Program supports application researches and encourages technology innovation.

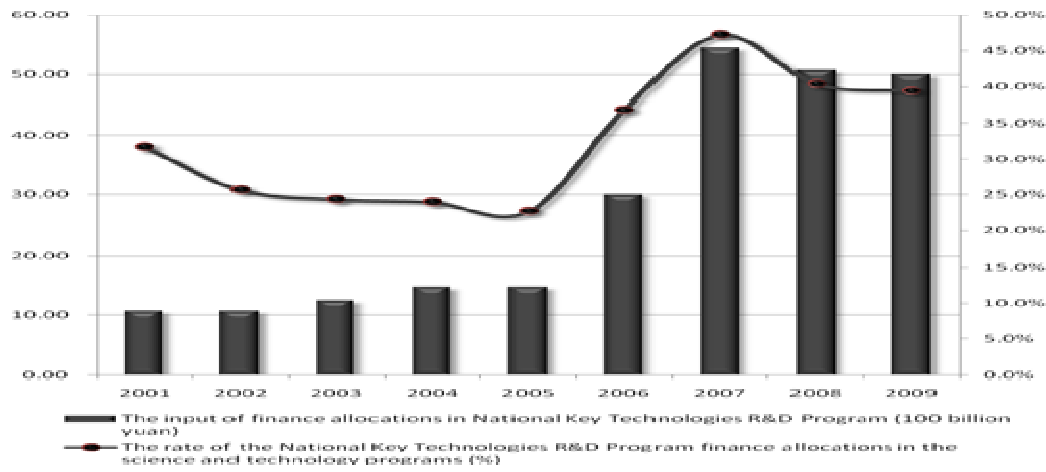


Figure 3: The Input of Finance Allocations in National Key Technologies R&D Program during 2001-2009.

Source: State Statistics Bureau, the Ministry of Science and Technology, *China Statistical Yearbook on science and technology* (2002-2010);

Table 3: The Input Rate in The 8 Fields in the National Key Technologies and R&D Program

(unit: %)

	Energy	Resource	Agriculture	Material	Manufacture	Information industry	Population and health	Public security(social undertakings)
2001	7.01	13.29	24.73	10.55	10.00	6.17	7.67	20.59
2002	6.39	4.08	22.27	9.13	7.64	10.32	20.73	19.45
2003	6.27	10.24	18.15	9.32	6.42	10.31	15.25	24.05
2004	3.63	6.83	19.96	10.55	2.93	7.67	24.91	23.52
2005	7.15	9.55	18.65	7.76	4.92	4.92	24.23	22.81
2006	12.80	13.19	26.29	6.83	6.85	9.46	8.21	16.37
2007	12.50	10.38	21.75	8.52	11.56	5.57	12.60	17.12
2008	10.85	15.12	20.14	10.16	8.92	9.19	9.36	16.26
2009	17.43	16.09	19.32	10.73	5.75	8.21	9.37	13.10

Source: State Statistics Bureau, the Ministry of Science and Technology, *China Statistical Yearbook on science and technology* (2002-2010);

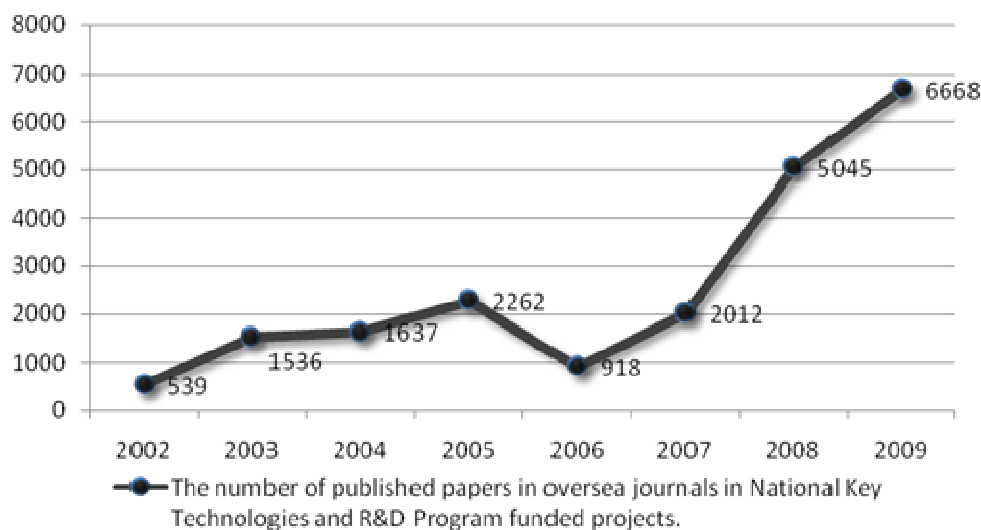


Figure 4: The Number of Published Papers in International Journals in National Key Technologies and R&D Program Funded Projects.

Source: State Statistics Bureau, the Ministry of Science and Technology, *China Statistical Yearbook on science and technology* (2002-2010);

Table 4: The Number of Foreign Patent Application and Authorization in The National Key Technologies and R&D Program

(Unit: items)

	No. of foreign patent application	No. of foreign patent authorization
2002	190	6
2003	65	14
2004	88	18
2005	186	32
2006	9	3
2007	37	9
2008	123	69
2009	199	38

Source: State Statistics Bureau, the Ministry of Science and Technology, *China Statistical Yearbook on science and technology* (2002-2010);

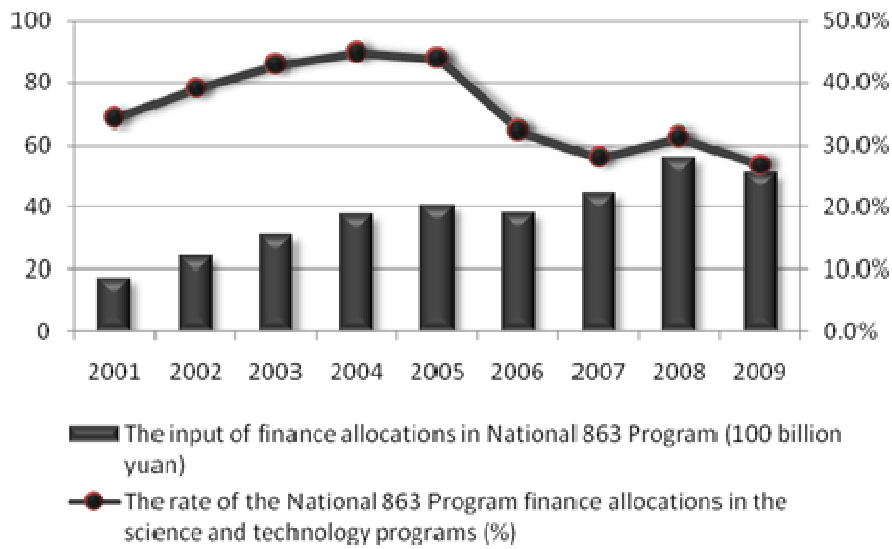


Figure 5: The Input of Finance Allocations in the National 863 Program

Source: State Statistics Bureau, the Ministry of Science and Technology, *China Statistical Yearbook on science and technology* (2002-2010);

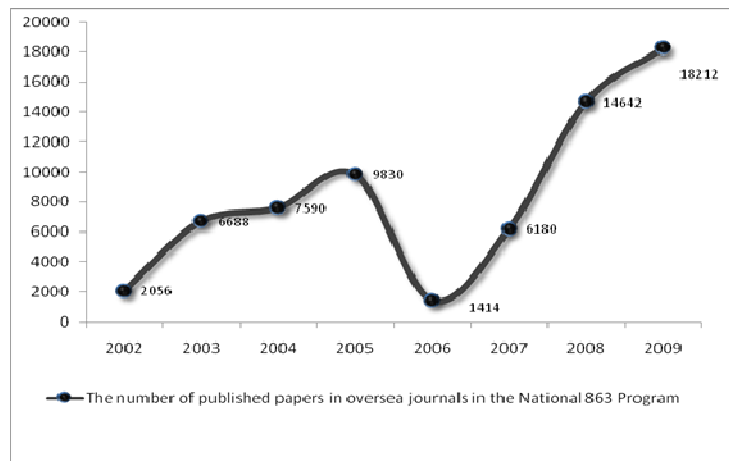


Figure 6: The Number of Published Papers in International Journals in the National 863 Program.

Source: State Statistics Bureau, the Ministry of Science and Technology, *China Statistical Yearbook on science and technology* (2002-2010);

It aims at improving the core competition of Chinese high-tech industry substantially in order to form a relatively complete national high-tech research and development system. It plays an important role in solving strategic, advanced and prospective high-tech problems related to the further development and security of the country.

Fig. 5 shows that the input in National 863 Program keeps increasing during 2001-2009. In 2008, the amount reaches 5.592 billion yuan, a more than two times growth than that in 2001 (1.695 billion yuan). There is a drop point in the general growth trend during 2001-2008. In 2006, the finance allocations from central government are 3.795 billion yuan, 230 million yuan less than that in 2005. After that, the growth trend continues until 2009 when the finance allocations are 477 million yuan less than that in 2008.

In general, the rate of finance allocations for the National 863 Program in the overall national program finances allocations increased first and then declined. During 2001-2004, the rate grows from 34.2% to 44.83%. In 2005, there is a slight decline with a rate of 43.87%. From 2006 on, there is an obvious decline trend among which the rate in 2008 is larger than that in 2007. However, from the overall perspective there exists a decline trend.

Analysis on the output of the National 863 Program. The National 863 Program concentrates on innovative exploration in key, creative and core technology. It has reached great achievement in seven fields, including bio-technology, space technology, laser technology, information technology, automation technology, energy technology and new material. Fig. 6 shows the number of published papers in international journals in the National 863 Program.

During 2002-2009, the total number of published papers in international journals in the National 963 Program is 66,612, taking up 10.6% of the overall amount in National Science and Technology. During 2002-2005, the number of published papers keeps increasing. In 2005, the amount is 9,830 which is 4.78 times more than that in 2002. From chart 6, we can see that there are only 1,414 published papers in 2006, which shows a sharp decline. From 2007, the number begins to increase again and in 2008, it breaks 18,212 which is 12.9 times more than that in 2006.

During 2002-2009, the National 863 Program has reached a great number of high-tech achievements with independent intellectual property right. Table 5 shows the number of foreign patent application and authorization.

During 2002-2009, the National 863 Program has applied 2,166 foreign patents of which 497 have been authorized. In 2002-2005, the number of foreign patent applications keeps increasing. In 2006, there is a sharp decline while in 2007-2009, the number increases year by year. On the other hand, the number of foreign patent authorization displays the same trend. In 2004 and 2005, the foreign patent authorizations are 142 and 134 respectively. However, in 2006, there are only 8 patents which have been authorized. After 2006, the number begins to increase again and in 2009 the number reaches 73.

The Input and Output of the National Basic Research Program (The National 973 Program)

The national 973 program faces basic research fields and major science researches which can satisfy the nation's essential and strategic requirement. It is based on the nation's major strategy. Its mission is to solve major basic scientific problems in the continual development of national economy, sustainable social development, national public security and science development to promote innovation ability in basic researches.

During 2001-2009, the finance allocations for the National 973 Program increases year by year. In 2009, the finance allocations are 2.6 billion yuan which are 4.3 times more than that in 2001. In 2001-2009, the total finance allocations amount to 11.483 billion yuan. The rate of finance allocations for the National 973 Program in the overall national program finances allocations is stable with the highest rate of 13.58% and the lowest 10.38%. Through a linear regression of the rate of finance allocations for the National 973 Program, we get an 11.6% corresponding line. It indicates that the rate fluctuate around 11.6%.

A comparative analysis on the input of all fields in National 973 Program. The National 973 Program concentrates on key scientific problems in the field of agriculture, energy, information, environment and resource, population and health, and material. It provides stable supports to a number of projects which are related to the needs of the national future strategic requirements and development. It aims at promoting the general innovative level and the ability to solve major problems in Chinese basic research to facilitate a sustainable development in the future.

We can see the rate distribution of input in every field in the National 973 Program during 2001-2009. The field of population and health takes the biggest amount, occupying 21.93% of the overall allocations. The second and third largest fields are environment and resource (18%) and material (16.15%).

Table 5: The Number of Foreign Patent Application and Authorization the Number of Foreign Patent Application and Authorization (Unit: items)

	No. of foreign patent application	No. of foreign patent authorization
2002	78	12
2003	305	44
2004	391	142
2005	538	134
2006	103	8
2007	170	30
2008	261	54
2009	320	73

Source: State Statistics Bureau, the Ministry of Science and Technology, *China Statistical Yearbook on science and technology* (2002-2010);

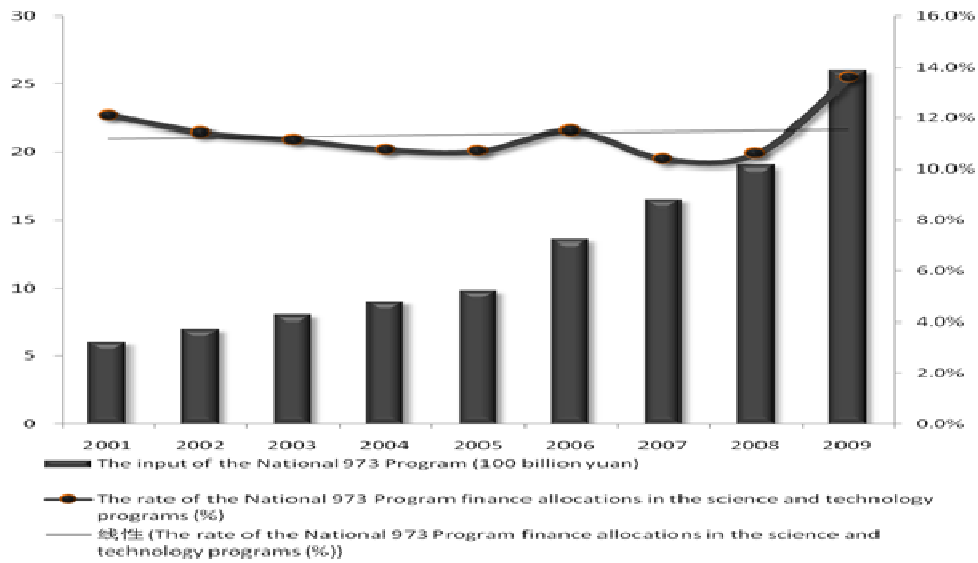


Figure 7: The Input of Finance Allocations in the National 873 Program

Source: State Statistics Bureau, the Ministry of Science and Technology, *China Statistical Yearbook on science and technology* (2002-2010);

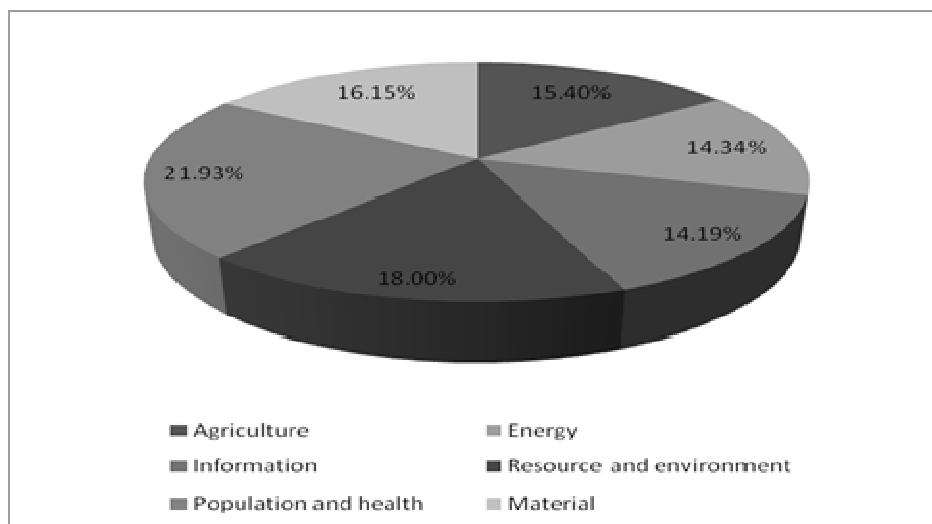


Figure 8: The Rate Distribution of Input in Every Field in The National 973 Program
 Source: State Statistics Bureau, the Ministry of Science and Technology, *China Statistical Yearbook on science and technology* (2002-2010)

Table 6: The Rate of Input in Every Field In the National 973 Program
 (unit: %)

	Agriculture	Energy	Information	Environment and resource	Population and health	Material
2001	17.46	13.49	13.86	24.09	15.62	15.48
2002	15.38	12.25	14.53	19.47	20.58	17.79
2003	13.87	13.22	15.37	22.02	19.22	16.30
2004	16.16	12.96	12.99	16.07	25.55	16.27
2005	13.73	11.96	14.42	18.44	26.40	15.05
2006	16.51	13.39	11.85	18.48	22.39	17.37
2007	14.99	16.10	16.38	15.79	20.02	16.72
2008	15.14	14.98	13.64	16.18	23.23	16.84
2009	15.85	16.67	14.09	16.44	22.18	14.77

Source: State Statistics Bureau, the Ministry of Science and Technology, *China Statistical Yearbook on science and technology* (2002-2010);

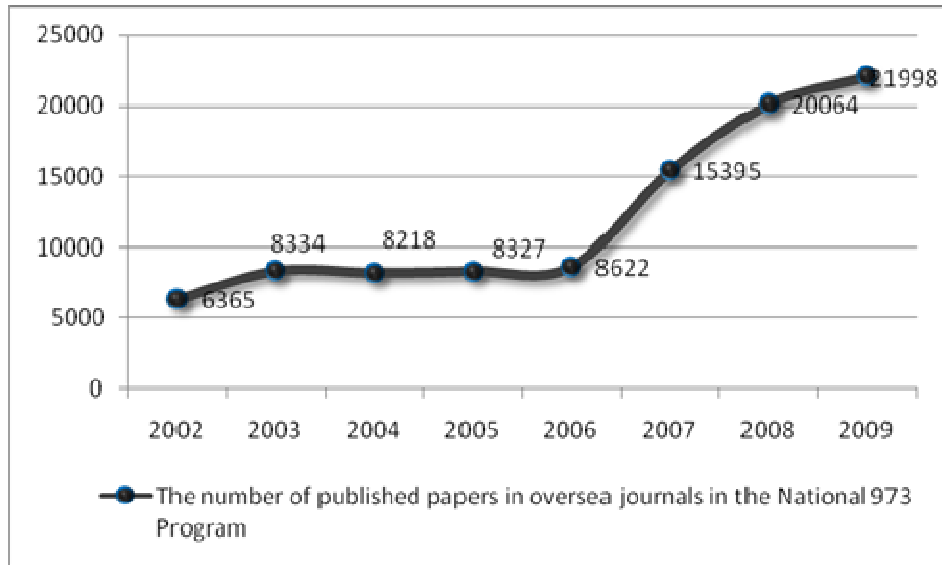


Figure 9: The Number of Published Papers in International Journals in the National 973 Program

Source: State Statistics Bureau, the Ministry of Science and Technology, *China Statistical Yearbook on science and technology* (2002-2010);

Table 7: The Number of Foreign Patent Application and Authorization in the National 973 Program

(Unit: items)

	No. of foreign patent application	No. of foreign patent authorization
2002	24	12
2003	22	8
2004	40	9
2005	29	23
2006	84	9
2007	69	21
2008	79	22
2009	112	29

Source: State Statistics Bureau, the Ministry of Science and Technology, *China Statistical Yearbook on science and technology* (2002-2010);

The data of 2002-2005 are from the number of foreign patent application and authorization in the Basic Research Program, including the National 973 Program and preliminary researches in the Basic Key Research Program.

Table 6 has clearly shows the change of the input rate in every field in this program during 2001-2009. The rate of agriculture fluctuates around 15% with a highest rate of 17.46% and the lowest one of 13.73%. Although there is a rate fluctuation in the field of energy, the general rates display a growth trend. In the field of information, the rate fluctuates around 14% with a lowest rate of 11.85% in 2006. The field of environment and resource displays a trend of decline. The rate of population and health hit its highest point of 26.4% in 2005 and after that the rate began to fall again. The highest rate in the field of material is 17.79% while the lowest point is 14.77%

Analysis on the output of the National 973 Program. The National 973 Program has reached a number of original achievements in the field of frontier science. This program has published a series of papers in international journals and took an important space in the world.

It should be noted that the data of 2002-2005 are from the published papers in international journals in the Basic Research Program which includes the National 973 Program and preliminary researches in the Basic Key Research Program. From the chart, we can see that there is an obvious increase trend. In 2006, the number of published papers in international journals grows rapidly and in 2009, the number hits 21,998, which is almost three times more than that in 2006.

The National 973 Program supports basic research and encourages knowledge innovation. It has reached original creative achievements in the trend of the world science development and promoted the independent creative ability continuously in national basic research. Table 7 shows the number of foreign patent application and authorization in the National 973 Program.

During 2002-2009, the National 973 Program has applied a total number of 459 foreign patents and 133 of them have been authorized. Moreover, the number of foreign patent authorizations shows a growth trend and reaches its first highest point of 84 in 2006. In 2009, the number of foreign patent applications reached 112 which is almost five times more than that in 2002. The number of foreign patent authorizations is above 20 in 2005, 2007, 2008 and 2009. In 2009, the number reaches 29, taking up 25.9% of the foreign patent applications.

CONCLUSIONS

During 2001-2009, the finance allocations in Chinese science and technology were increasing as well as the number of published papers in international journals and the foreign patent application and authorization. The National S&T Programs play a leading role in Chinese science and technology development and

make great contribution in promoting the development of Chinese science and technology.

In China, the central government allocates finance to support the national science and technology programs. It is a representation of the policy arrangement of pooling resources to achieve big goals in development of science and technology in China. The input of national science and technology programs and the output of published papers in international journals and the number of foreign patent applications and authorizations demonstrate that it is effective to undertake the policy arrangement of pooling resources to achieve big goals in development of science and technology in China. This arrangement shows certain advantages in dealing with international competition in the field of science and technology.

REFERENCES

- [1] Annual. (2001-2010). National Natural Science Foundation of China. Retrieved from <http://www.nsf.gov.cn/Portal0/default124.htm>
- [2] National Bureau of Statistics, Ministry of Science and Technology. (2011). *China Statistical Yearbook on Science and Technology (2002-2010)*. Beijing: China Statistics Press.
- [3] The Ministry of Science and Technology of the People's Republic of China. (2011). Annual Report of State Programs of Science and Technology Development (2002-2010). Retrieved from <http://www.most.gov.cn/>
- [4] "Science and Technology Project Management Questions & Answers" editorial board. (2008). *Science and Technology Project Management Questions & Answers*. Beijing: Scientific and Technical Documents Publishing House Press.
- [5] Shuhua, Zhong (2008). Evaluation Methodology of Independent Innovation in National Science and Technology Programs. *R&D MANAGEMENT*, 12, 101-107.

ABOUT THE AUTHORS

Lu, Cui. (1985-). Female. Jiao zuo, Henan province. Doctoral candidate, research direction: the policy and management of science and technology

Shuhua, Zhong. (1957-). Male. Bijie, Guizhou province. Doctoral tutor with special government allowances of the State Council, research direction: technology innovation, the policy and management of science and technology

Address: Room 420, College of Public Administration, Huazhong University of Science and Technology, 1037 Luoyu Road, Hongshan district, Wuhan, China, 430074

Telephone:
15271819768(mobile)

027-87543047(office);

E-mail: cuilu136138@qq.com