

## TECHNOLOGY INNOVATION POLICY FOR THE BIOECONOMY

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### ABSTRACT

Korea has a strong potential on biotechnological research and industrial capabilities. The Korean government recognized biotechnology was the key factor that will allow the nation to be a leading country and had begun promoting biotechnology after enacting of the Genetic Engineering Support Act [now known as the Biotechnology Support Act in 1995] in 1983. When formulating of Basic Plan for Biotechnology Support (“Biotech 2000”) in 1993, the government started to coordinate governmental biotechnology policies. In 2006, the government established the 2nd Basic Plan for Biotechnology Support (“Bio-Vision 2016”) in an effort to achieve a goal of making Korea a biotechnology leader in the world, according to the vision of realizing a sound health life and prosperous bioeconomy. But the governmental R&D investment on biotechnology began to increase rapidly in the 2000s. In 2013, US\$2.6 billion was invested. And it’s nearly 18.4% of total governmental R&D investment in Korea. Korea has taken great strides to set up an efficient institutional systems related to the biotechnology promotion.

In this paper, using policy analysis model to illustrate, I demonstrate how the suggested model helps to set the policy formation and implementation analysis of Korean biotechnology. According to model, four categories of indicators play a major role in this analysis: inputs, activities, outputs, and outcomes. The methodologies combine qualitative and quantitative methods, such as peer reviews, interviews, and S&T indicators.

Eight ministries of Korean government were related to biotechnology promotion and implemented many governmental programs. Total production has increased by 26% from US\$1.9 billion in 2002 to US\$2.4 billion in 2004. There was also a drastic rise of the number of biotechnology start-ups. It was increased from 167 bio-venture companies in 1999 to 600 in 2001. And there has been a significant increase in the number of biotechnology research papers that are written by Koreans and published in international top academic journals such as Nature, Cell, and Science from 1 in 1996 to 10 in 2004. From 2000 to 2003, the number of Korean biotechnology patents within the U.S. has increased by 85% up to 204. Also international achievements in pharmaceutical development were achieved. For example, the 1st Korean global new drug, “Factive”, was approved by U.S. FDA in 2003.

But the total productivity of governmental R&D investment is not high yet in Korea. And now, the policy direction of new government is shifted to ‘creative economy’ and key concepts are ‘creativity’ and ‘convergence’. Therefore the promotion of biotechnology start-ups is very important and similar to the state of governmental support from 2000 to 2005. I conclude by developing a policy agenda to guide the national paradigm shift to address current and future challenge in Korea. And the experiences in Korea show various policy implications that will render especially for developing countries.

**Keywords:** policy analysis, policy implementation, biotechnology, bioeconomy, creative economy

## **INTRODUCTION**

Korea's economic growth was mainly supported by the development of science and technology. Policy trends changed from industry oriented to technology oriented. From the 1960s, science and technology policy focused on building R&D infrastructure, promoting R&D and enhancing technology innovation, in turn.

Today, Korea is one of the most competitive countries in some technology fields, such as DRAM semi-conductors, displays, and mobile phones. For instance, in the case of DRAM semi-conductors and displays, Korea accounts for 43.3% and 63.4% of the world market share, respectively.

Korea now faced many international and domestic challenges. First of all, as developed countries recognize Korea as a competitor, they keep Korea in check through patent lawsuits and other means. Along with this, developing countries are chasing Korea with their fast economic growth. Internally, as Korea becomes an aging society, many people are concerned about the possibility for potential growth rate to decline.

In order to overcome these challenges, the capability for technology innovation is more important than anything else. Korea has high competitiveness in some technology fields, but the overall technology level remains 60 to 80 % of that of developed countries. In particular, technology trade deficit structure continues due to the lack of important fundamental technologies.

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According to a recent OECD report, an emerging concept, Bioeconomy, is proposed. In this paper, the bioeconomy is defined as, a new concept, covers a broad range of economic activities, all benefiting from discoveries, and related products and services arising out of the biosciences.

In this paper, using policy analysis model to illustrate, we report on our experiences in policy formation and implementation of Korean biotechnology innovation.

## **METHODOLOGY**

In this context, we carried out a policy analysis and review on the biotechnology innovation.

This policy analysis was performed with two main purposes. One is in-depth analysis for the biotechnology innovation between 1994 and 2012. The others are suggestions in the policy directions to promote the biotechnology innovation in Korea according to the in-depth analysis above.

We suggested conceptual analysis model with reference to OECD's "Policy Evaluation in Innovation and Technology: Towards Best Practices". According to model, four categories of indicators play a major role in this analysis: inputs, activities, outputs, and outcomes.

The approach taken in this analysis combined with qualitative and quantitative evaluation methods, such as peer reviews, in-depth interviews, and S&T indicators.

## **MAIN FINDINGS**

Historically, Korea has a sound basis for biotechnology research and related industrial activities, arising from a substantial food industry with a long tradition of fermentation for such products as soy sauce and Kimchi, a popular fermented food. The industrial production of alcoholic beverages, amino acids and antibiotics by fermentation is already highly competitive in the world market.

Therefore the total investment by government is not yet sufficient, the investment in biotechnology has been increasing significantly every year, reflecting government policy to promote biotechnology strongly. Also, Korean government now recognizes that biotechnology is the key discipline that will allow the nation to become one of the top developed countries in the 21<sup>st</sup> century. Such a view strongly encourages the national policy makers to support the life sciences, and biotechnology in particular, as the highest priority in R&D investment in order to enhance national industrial competitiveness.

## **POLICY FORMATION**

It was not until the 1980s that a systematic effort to develop biotechnology was launched at a national level. Laying the ground work in the early 1980s, when the Korean economy was attempting to make the transition from traditional manufacturing technology to more advanced technologies, the expansion of biotechnology was considerable. The development of biotechnology was recognized as a national priority by the government and industry leaders, and the first successful result of this was the establishment, in March 1982, of the Korean Genetic Engineering Research Association [now known as the Korea Biotechnology Research Association, or KBRA], a consortium of 19 companies with active interests in biotechnology. In the same year, the Ministry of Science and Technology (MOST) included biotechnology as one of the strategic areas of national technological development.

An important milestone in government biotechnology policy was the enactment of the Genetic Engineering Promotion Law [now known as the Biotechnology Promotion Law] in 1983, which contributed greatly to the establishment of a solid foundation for biological science and technology in Korea. According to enactment of 'Biotechnology Promotion Law' in 1983, Korean government established the Biotech 2000 in 1994. This plan contains national goal, objectives by stage, scale of investment, and framework. Also, this system is implemented by a total of eight ministries including the Ministry of Education & Human Resources Development, Ministry of Agriculture & Forestry, Ministry of Commerce, Industry and Energy, Ministry of Health and Welfare, and so forth, all under the supervision of the Ministry of Science and Technology.

With the help of this law, the Genetic Engineering Center [now the Korean Research Institute of Bioscience and Biotechnology, KRIBB] was established in 1985. Many universities also opened new departments specializing in genetic engineering and biotechnology, and started to establish genetic engineering research centers within the universities. Realizing the growing worldwide biotechnology market and the need to cultivate the domestic bioindustrial environment and to restructure the industrial sector, the Bioindustry Association of Korea was established in 1991. Since then, the scientific environment in Korea has been improving spectacularly and the funding for biotechnology research has been increasing rapidly, along with the Korean economy.

In 2006, Korea has formulated the 2nd Basic Plan for Biotechnology Support based on the 1<sup>st</sup> one. The government established the 2nd Basic Plan for Biotechnology Support (“Bio-Vision 2016”) in an effort to achieve a goal of making Korea a biotechnology leader in the world, according to the vision of realizing a sound health life and prosperous bioeconomy.

## POLICY IMPLEMENTATION

The Korean government is usually pursuing innovation in three directions. First, Korean government built a consolidated administrative system for S&T innovation policy, human resources development, industrial and regional innovation policy. Also for budget allocation, the government puts great emphasis on increasing the efficiency of R&D investment. Secondly, the Korean government is attempting to create new growth engines for the economic growth and national development. Lastly, it focuses on cultivating S&T human resources through efficient training programs.

### Inputs

Biotechnology has been deemed as a promising technology and one of so-called next-generation growth engines along with information technology of Korea. Against this backdrop, the Korean government’s R&D expenditure on biotechnology has significantly increased for the last ten years.

But the governmental R&D investment on biotechnology began to increase rapidly in the 2000s. In 2013, US\$2.6 billion was invested. And it’s nearly 18.4% of total governmental R&D investment in Korea. Korea has taken great strides to set up an efficient institutional systems related to the biotechnology promotion.

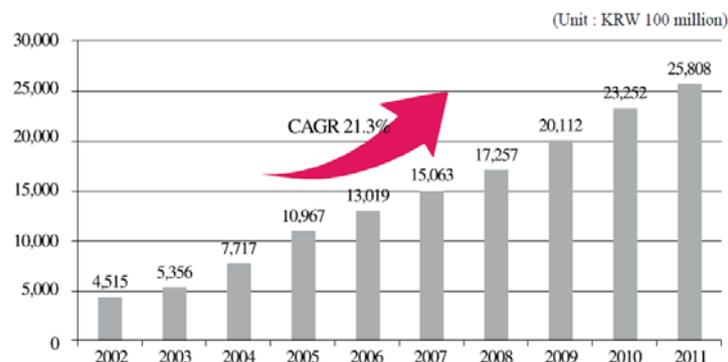


Figure 1. Government Investment in Biotechnology (2002~2011)

Korea has been strategically promoting the biotechnology sector emerged as a solution to the problems of aging, environment and energy, by strengthening investments for securing the original technologies and industrial infrastructure. Korea is increasing government R&D budget and centralized investment in these strategic areas.

### Activities

Bio R&D programs of major ministries are composed of various sub-programs.

Based on their respective characteristics, biotechnology centers will be developed nationwide according to their areas of specialization. A total of 25 biotechnology centers will be fostered as

innovation clusters, which will create added value and serve as an incubator for world-class biotechnology companies.

## Outputs

Publication capacity of papers from Korea in biotechnology is rapidly growing every year, and quality of papers is also increased upon publishing in highly prestigious international journals.

Number of papers published in the prestigious international journals is on the sharp rising, in particular published in world top academic journals such as Nature, Cell and Science, 43 top-class publications in 2012.

And Korea's international ranking in terms of total number of SCIE publications rose.

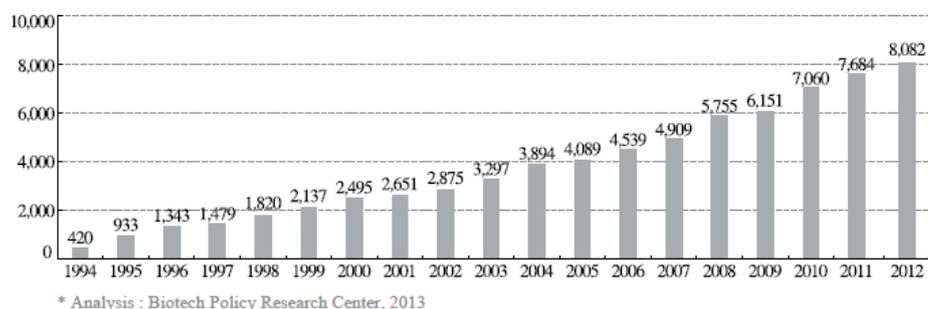


Figure 2. Publications from Korea in Biotechnology by year

Table 1. Domestic Publications in NSC

Year	'01	'02	'03	'04	'05	'06	'07	'08	'09	'10	'11	'12
NSC publications total	14	19	13	18	29	28	26	28	38	47	44	43
BT-related NSC publications total	11	11	11	10	23	18	19	15	21	28	25	22
BT ratio (%)	78.6	57.9	84.6	55.6	79.3	64.3	73.1	53.5	55.2	59.5	56.8	51.2

\* Analysis : Biotech Policy Research Center, 2013

The remarkable growth of patents in biotechnology is in terms of quantity as well as quality.

From 1994 to 2012, the number of Korean biotechnology patents within the U.S. has increased while the total number of U.S. biotechnology patents has increased in the same time period. Korea is one of the fastest growing countries in terms of the number of patents registered in the United States. Technological strength climbed.

Table 2. No. of Patents Published by Korea in the US

Year	1994~1997	1998~2001	2002~2005	2006~2010	2011~2012
No. of Patents	48	178	208	523	453
TS Index Ranking	17th	15th	16th	16th	14th

\* Analysis : Korea Institute of Patent Information, 2013

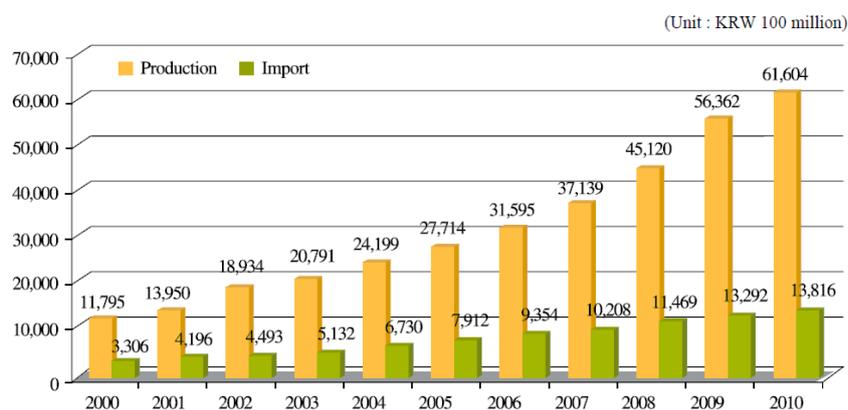
**Table 3. Technology Strength of Korea Based on US Patents**

Technology Classification	2002 ~ 2005		2011 ~ 2012		Increase (b/a)
	TS(a)	Ranking	TS(b)	Ranking	
Bioprocess	10.71	12	15.04	10	1.4 Times
Sensors / Diagnostics	10.97	17	11.10	17	1.0 Times
Proteomics	1.64	17	1.93	15	1.2 Times
Animal & Plant Cell Culture	1.26	17	2.58	14	2.0 Times
Biological Resources / Bioprospection	1.51	14	3.01	8	2.0 Times
Genomics	3.78	15	4.01	19	1.1 Times
Antibody	0.38	13	4.15	8	10.9 Times
Enzyme Engineering	1.76	16	2.36	12	1.3 Times
Bio-Pesticide Development	2.52	13	0.43	20	0.2 Times
Transgenic Animals & Plants	0.25	19	1.22	13	4.9 Times
Biomedicines	9.20	22	59.66	10	6.5 Times
Environmental Biotechnology	8.07	6	1.86	11	0.2 Times

\* Analysis : Korea Institute of Patent Information, 2013

## Outcomes

The biotechnology market in Korea has been continuously growing, with the increase in production. In particular, the biopharmaceuticals industry has the highest market share.



\* Source : Ministry of Trade, Industry and Energy (2012)

**Figure 3. Production & Export from Bioindustry (2000~2012)**

The number of biotechnology companies in Korea is 913, including 221 venture companies and 158 technically innovative companies in Korea.

**Table 4. Biotechnology Companies in Korea**

Year	No. of Companies	Employees	Export	Import
2006	794	17,316	13,502	9,354
2007	834	20,236	14,715	10,208
2008	851	20,520	19,038	11,469
2009	853	22,817	27,287	13,292
2010	913	32,004	27,445	13,816

\* Source : Ministry of Trade, Industry and Energy (2012)

With the governmental strong supporting policy, high-quality human resources in biotechnology have highly been promoted.

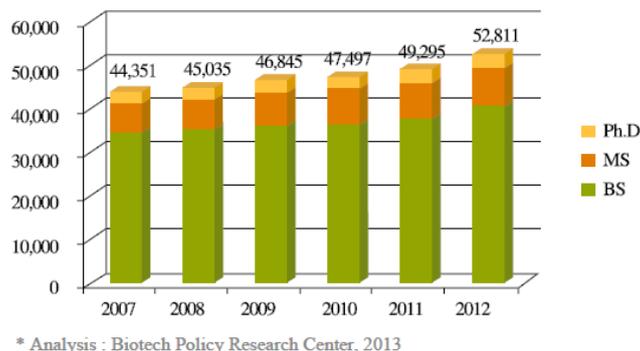


Figure 4. Human Resources in Biotechnology

Korea has succeeded in meeting the international standard of clinical trials on new drugs and made an achievement of being the world top 10 in clinical trials, which came from its 10 years of effort.

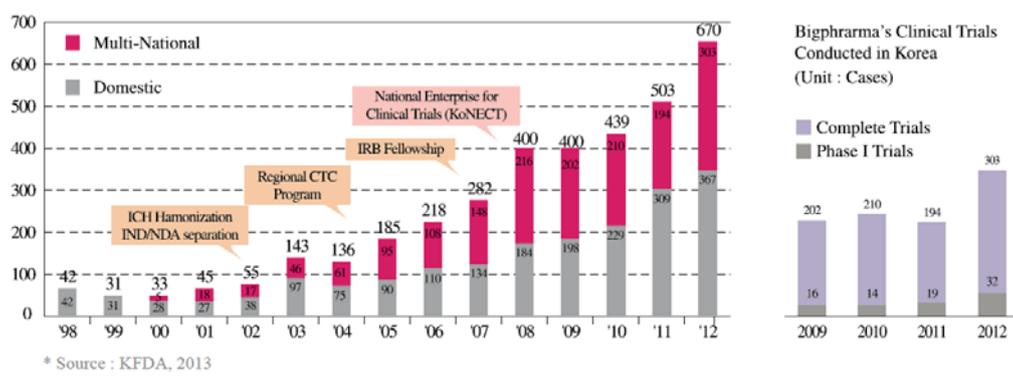


Figure 5. Clinical Trials Approved by KFDA

The Korean government has been fostering the Bio-cluster System and creating specialized hubs and R&D complexes in each district with the aim of strengthening its competitiveness in biotechnology, which is expected to enable the setup of interregional human, technical and industrial networks, local innovation and the balanced development of biotechnology industries.

## CONCLUSION AND POLICY IMPLICATIONS

However, basic and fundamental research in Korean biotechnology is still considered to be at an immature stage. In order to enhance international competitiveness in biotechnology, a national strategic plan is necessary, based on close cooperation between industry and government, to create a harmonized, consistent plan to foster biotechnology. Current status of Korean biotechnology is largely at the stage of improving technologies imported from the advanced countries; however, efforts are also partially targeted at developing innovative products.

According to the policy analysis in the four criteria, we demonstrate that the innovation policy in biotechnology-related was well-formulated with reflecting international environments and structures under the administration system. Though communication among the ministries and the

policy implementation, following subsequent effects were at an average level. Concerning changes in the recent policy environments, it is reasonable for the government to support continuously the biotechnology innovation. The main results of policy analysis are;

Firstly (relevance), Korea was on the way behind developed countries in setting up integrated, systematic national S&T strategic (basic) plan, but was well-formulated by nurturing biotechnology / bioindustry at national level, lack of cooperation within the S&T related ministries of Korea. Secondly (efficiency), Korean government organized basic national system well, but questionable in research plan due to not effectively connected with top down approaches. Thirdly (effectiveness), the expected outcomes were only partially attained, by investigating in-depth analysis on R&D practical solutions and implementations is necessary for the industry as a whole. Finally (utility), infrastructure has been established, however, fundamental technology for long-term strategic supporting and industry technology for practical ranges. As the final stage of the biotechnology innovation policy analysis, we have proposed some policy directions to promote biotechnology innovation in Korea. As a future direction of the national biotechnology innovation, it is to be aiming at 'Realization of an affluent Bio-Healthpia' by accomplishing the world's top five in national competitiveness of the strategic biotechnology field. 'Formation of Knowledge Basis', 'Promotion of Core Capability', and 'Initiative of Industrial Innovation' were suggested. This is an overview of 2<sup>nd</sup> Biotechnology Basic Plan. Korea aims to become the world's seventh largest bio-industry country.

If Korea's technology innovation strategies are fulfilled more thoroughly, it is expected that Korea will be an innovation hub where international resources are attracted, combined and exchanged. We hope this paper has been helpful to understand Korea's biotechnology innovation policy.

## REFERENCES

### Book

Ministry of Education, Science and Technology, (2013), Education, Science and Technology in Korea 2012

Ministry of Science, ICT and Future Planning, (2013), Biotechnology in Korea 2013

Ministry of Science, ICT and Future Planning, (2013), The Third Science and Technology Basic Plan: Opening a New Era of Hope Fueled by the Strength of Science and Technology

### Journal Article

Kwan Yong Choi, Kyung-Soo Hahm, Sang-Ki Rhee, and Moon Hi Han, (1999), An overview of biotechnology in Korea. TIBTECH, 17, 95-101.

### Proceedings

Sung-Goo Han, (2014), Evolutionary Perspective on STI Policy in Korea: Presidential leadership on STI Policy". In Proc. STI Policy 2014 Conference. Delhi

Sung-Goo Han, (2014), The Opportunity and Challenge of STI Policy in Korea. In Proc. Asian Association of Learning, Innovation, and Co-evolution Studies (ASIALICS) 2014. Daegu

Sung-Goo Han, (2014), The Effects of Institutional Accountability on the Outcomes of Technology Innovation in Korea. . In Proc. European Conference on Economics, Politics, and Law (ECPOL) 2014.

Sung-Goo Han, (2013), Inter-ministrial Competition and Cooperation in Korea: Focusing on Emerging Technology Policy. In Proc. 2013 AGPA Annual Conference. Singapore

Sung-Goo Han, (2013), Green Growth and Innovation Strategy for Sustainable Development in Korea. CASS (Chinese Academy of Social Sciences) Academic Seminar. Beijing

Sung-Goo Han, (2012), The Promise, the Reality, and the Future of Biotech in Korea: New perspectives on economic growth and technological innovation. KABIC (Korean American bioindustry Council) Seminar. Harvard

Sung-Goo Han, (2011), Policy Coordination of Biotechnology R&D. In Proc. International Association for Management of Technology (IAMOT) Conference. Miami

Sung-Goo Han, (2010), Approach to Developing the Science of STI Policy in Korea. In Proc. International Association for Management of Technology (IAMOT) Conference. Cairo

Sung-Goo Han, (2008), Policy Analysis and Evaluation on Biotechnology R&D in Korea. In Proc. International Association for Management of Technology (IAMOT) Conference. Dubai