Technology Foresight Activities in Korea 
and in Catching-Up Countries

Taeyoung Shin¹, Soon-ki Hong² and Hariolf Grupp³

Abstract

This article is on technology foresight in selected countries which were politically 
dependent (colonial) before the War, and considered as "under-developed" in the 
past-war period. Most of them show considerable economic dynamism in the 1990s 
which is not always based on own scientific and technological capability. For this 
group of countries, national exercises in technology foresight are likely to be an 
important tool in planning the strategic direction for science and technology 
development in order to catch up economically, but also socially. In Korea, which is 
an OECD member since recently, comparative advantage based on factors such as 
low wages and protected industries is no more effective as the economy is now 
widely open to the world. Foresight is being used for looking out at comparative 
advantages based on own knowledge-creating activities. In south-east Asian 
countries, foresight is still in an infant stage, but most of these have medium-term 
planning cycles and undertaken longer-term vision studies. In South Africa, a 
national foresight is running as is adapting foresight process to make the large 
national research organization fit. In Latin America, an agenda has been set up 
which describes the volition of several countries to engage in foresight activities 
with different approaches.

¹ Policy Adviser, Ministry of Science and Technology, 1 Joongang-Dong, Kwacheon, Kyunggi 427-760, Korea, Tel: (82-2) 500-3248 / Fax: (82-2) 503-7656.

² Associate Professor, Department of Industrial Engineering, Sungkyunkwan University, 300 Chonchon-Dong, Suwon 440-746, Korea, Tel: (82-331) 290-7596 / Fax: (82-331) 290-7610.

³ Deputy Director, Fraunhofer ISI, Karlsruhe, and part-time professor, Faculty of Economics and Management, Technical University, Berlin, Germany.
1 Introduction

In many textbooks on economic development, the world is divided into the industrialized "North" and the developing "South". Indeed, many "southern" countries were politically dependent on other powers or were colonies before World War II. In the decades after the War, they were still "undeveloped" or at least "underdeveloped"; for some of them, political independence immediately worsened economic welfare for a while. By the 1990s, however, this group of countries is coming up with considerable economic dynamism which is not always based on a sound national infrastructure in science and technology (S&T). Hence, the national foresight exercises in the "South" may become more important than those in the "North". It may help in defining the strategic direction for selective and indigenous science and technology development in order to catch up further economically and socially.

At the turnaround of the century, Korea and the catching-up countries are likely to reconsider the role of science and technology within their national innovation systems. In Section 2, Korea’s national S&T system is briefly described, whereas in Section 3 technology foresight activities in Korea, and, in Section 4, the Korean Delphi, in particular, are dealt with. Korean development trajectories are considered in Section 5, south-east Asian, South African and Latin American trajectories follow in Sections 6-8, before we conclude. Among the countries studied, Korea is the most advanced in S&T and also in the application of technology foresight. It is now an OECD member. In relation to the other catching-up countries considered we allocate considerably more space to the Korean experience.

2 Korea’s national science and technology system

In the process of industrialization during the last three decades, the main thrust of economic development in Korea were high quality workers with lower wages, high rates of savings and protection of domestic industries. However, Korea’s comparative advantage depending on those factors is no more effective as idle resources are no more available and the economy is widely open to the world. The economic environment is rapidly changing as globalization prevails, and therefore needs for changing public policies are increasing for a successful transition to a knowledge-based economy. It is implied that Korea should look for other sources of the competing edge, particularly focusing on S&T or knowledge-creating activities; that is, innovation-based strategies for development are needed. [1]

In Korea, many ministries or agencies perform their individual functions related to

---

4 In this article, by "Korea" we mean the Republic of Korea.
science, technology and innovation. The Ministry of Science and Technology (MOST) serves as the "lead agency," specializing in common, interdisciplinary and strategic areas, and assumes responsibility for overall coordination of all other ministries and agencies. For the last three decades, MOST has been responsible for leading S&T activities in both the public and the private sectors. But as the society becomes more diversified over time, and the importance of science and technology increases in wide-ranging socio-economic activities, S&T responsibilities and resources have been rendered to other ministries. Although the role of MOST is defined to carry out its own S&T operations and policies it is difficult for MOST to coordinate the policies and activities of other ministries and agencies. It is mainly because the national innovation system is in a relatively weak position, and lacks workable institutional mechanisms. Major ministries responsible for S&T activities next to MOST, particularly in response to changing national needs, are the Ministry of Trade, Industry and Energy (MOTIE), the Ministry of Information and Communications (MIC), and the Ministry of Education (MOEd), among others.

According to such an evolution of the government structure and changes in policy-making mechanisms, many agencies for their own R&D management had been established, including technology foresight, planning, evaluation and control, etc. As shown in Table 1, eight ministries are now engaged in R&D activities and have their own agencies for R&D management. Those agencies are responsible for technology foresight, planning, evaluation and resource allocation, etc. However, most of them started their operation at the beginning of 1990s, so that their respective activities are still focusing on developing methodologies and uses. It is notable in such a situation that MOST with an accumulation of three-decade experiences in R&D management provided a framework for technology foresight activities in line with R&D management.

One of the successful models of technology foresight was made when the MOST delivered, in 1992, a national R&D program called the Highly Advanced National (HAN) Projects. The purpose of the HAN Projects was to increase competitiveness of domestic industries by increasing indigenous capability of science and technology. It was the first attempt in a systematic way, calling for inter-ministerial collaboration in S&T planning.5

Table 1: R&D management agencies of the government sector in Korea

<table>
<thead>
<tr>
<th>Ministry of</th>
<th>R&amp;D Management Agency</th>
<th>Area</th>
<th>Start year of R&amp;D programs</th>
</tr>
</thead>
</table>

5 It was pointed out that the S&T policy in Korea had lacked integrity of S&T planning. This is by and large due to the diversified system of S&T policy-making.
<table>
<thead>
<tr>
<th>Science and Technology Policy Institute (STEPI/KIST)</th>
<th>Various areas</th>
<th>1982</th>
</tr>
</thead>
<tbody>
<tr>
<td>Korea Science and Engineering Foundation (KOSEF)</td>
<td>Target-oriented basic research</td>
<td>1987</td>
</tr>
<tr>
<td>Industrial Technology Policy Institute (ITEP/KITECH)</td>
<td>Industrial technologies</td>
<td>1987</td>
</tr>
<tr>
<td>R&amp;D Management Center for Energy and Resources (RACER)</td>
<td>Alternative energy</td>
<td>1988</td>
</tr>
<tr>
<td>Institute of Information Technology Assessment (IITA/ETRI)</td>
<td>Information and communications</td>
<td>1991</td>
</tr>
<tr>
<td>Korea Institute of Construction Technology (KICT)</td>
<td>Construction</td>
<td>1995</td>
</tr>
<tr>
<td>Korea Institute of Health Service Management (KIHM)</td>
<td>Medical care</td>
<td>1995</td>
</tr>
<tr>
<td>R&amp;D Promotion Center for Agriculture, Forestry and Fishery (ARPC)</td>
<td>Agriculture, forestry and fisheries</td>
<td>1995</td>
</tr>
<tr>
<td>National Institute of Environmental Research (NIER)</td>
<td>Environment</td>
<td>1992</td>
</tr>
<tr>
<td>Korea Research Foundation(KRF)</td>
<td>Academic research</td>
<td>1996</td>
</tr>
</tbody>
</table>

An evaluation of the HAN Projects three years after of its initiation showed that the HAN Projects turned out to be quite successful. This can become a standard model for formulating S&T policy and planning the national R&D program. A primary lesson from the foresight of HAN Projects places an emphasis on the concerted action among different interest groups and resource allocation by priority setting. Such a framework seems now to be inevitable and is frequently employed for major policy making, which was also employed when the MOST initiated to enact the S&T special law in 1997 - targeting at a substantial increase in S&T capability through the five-year plan for S&T development.

However, since only limited number of experts participate in this HAN Projects-related foresight activities (see Section 3), it is required that the formulation of a new R&D program should be based upon more extensive information produced in a systematic way as well as supported by wide-ranging consensus among related actors in the socio-economic system.
3 Technology foresight activities in Korea

As investment in science and technology is continuously increasing to cope with a rapidly changing environment, technology foresight activities are required for priority setting, R&D evaluation and control, etc. The foresighting activity in Korea is historically not long-rooted, but it is recently observed that various R&D organizations carry out actively technology foresight.

The purpose of this section is to review the foresight activities in Korea. An additional discussion of the first Korean Delphi will follow in the next section in more detail. The foresight activities in Korea are undertaken by and large by the government sector. Due to lack of experience, however, the responsible organizations are still developing methodologies and uses for their own policy formulation. Only the first Korean Delphi has had a substantial stimulation to both the public and private sectors. As technology foresight or forecasting is a relatively new concept in Korea, the activities are undertaken in various ways. Let us first consider the foresight process preceding the HAN Projects. This particular foresight process took about one year and more than 400 experts had participated from industry, academe and government. The foresight procedure included three stages; preliminary stage, main foresight, and commitment stage.

In brief, at the preliminary stage, coordination and communication for the new national R&D program took place between the ministries concerned including various interest groups. A foresight committee was also created. Next, at the main foresight, there were four phases. These included reviewing information about factors related to science and technology, addressing the objectives and selecting the candidate technologies for the R&D program. A survey for the candidate technologies was undertaken for priority setting, and finally the committee selected eleven areas of science and technology. Budget allocation and control and R&D evaluation followed at the final stage. [2]

Besides the HAN Projects, it was not until the late 1980s that a major concern on technology forecasting at the national level was made firstly by a research team of the Science and Technology Policy Institute (STEPI), affiliated to KIST (the Korea Institute for Science and Technology). Since then, attention had been paid constantly, but not rigorously, to foresight, mainly due to lack of pertinent experts and research funds at the beginning. There had been a series of efforts for technology forecasting in the early 1990s. [7] In 1992, the research team was able to

6 Then Dr. Shin was head of the Tech. Forecasting Research Dept., STEPI.
7 These were patient efforts devoted by the research team being stimulated and motivated by the Japanese Delphi. The research team invited experts, such as John Irvine from the United Kingdom, Kondo Satoru from Japan and Professor Martino from the United States, to learn more
carry out a Delphi study for the long-range technology forecasting. [3] A major step to the practice of technology forecasting could be made in 1993. The Korean Delphi, characterized by three-round Delphi, was undertaken through three stages including preliminary activities, pre-foresight and main foresight. This will be discussed in detail in the following section.

If we consider the foresight activities in other government departments, we have to mention MOTIE which has undertaken R&D programs related to industrial activities for the last ten years. Under the auspices of MOTIE, a non-profit research institute, the Korea Institute of Industrial Technology (KITECH), is responsible for industrial R&D. KITECH established the Institute of Industrial Technology Policy (ITEP), which is responsible for management of R&D funded by MOTIE, including selection of technologies, fund allocation, and evaluation, etc. For the effective performance of industrial R&D, ITEP regularly undertakes technology foresight. Its foresight activities focus mainly on problem solving in the short term, usually less than five years. Its foresighting activities depend by and large on regular surveys of technologies needed by the industrial sector. In so doing, major criteria in selecting new technologies are the generic and core type of industrial technologies, import-substitution technologies, technologies creating high value-added, and environment-friendly technologies. ITEP also makes efforts to continuously develop various methodologies, and to refine its foresight activities. The primary purpose of ITEP’s current foresight activities is to find out technological opportunities and to set the priority over competing opportunities, upon which the Five-Year Plan for Development of Industrial Technology 1996-2000 will be revised.

Since MIC started its own R&D operation in the beginning of the 1990s, the investment in the information technologies has been sizable. It took over one of the Non-Profit Research Institutes (NPRIs), the Electronics and Telecommunication Research Institute (ETRI), from MOST to concentrate more on information technologies. Under the auspices of ETRI, the Institute of Information Technology Assessment (IITA) is responsible for technology foresight. IITA in particular undertakes technology foresight activities focusing more on the normative approach. MIC has formulated a policy for information technology, making a giant investment in constructing nation-wide information super highways by 2010. If such investment is in schedule, communication services provided will be greatly improved in the near future. Therefore, in case of the IITA, the demand side of

about technology forecasting, and continuous seminars and discussions were organized by the team.

8 Martin & Irvine [4] divided foresight activities into pre-foresight, main foresight and post-foresight. Since the Korean Delphi focused mainly on production of S&T information, the post-foresight activity was not carried out. However, the Korean Delphi provided valuable information for policy formulation afterwards.
technologies is the major factor to be taken into account when the R&D plan is formulated. Yet, (component) technologies to make new services feasible are addressed partly in terms of a S&T-push approach.

Thus, we observe that the technology foresighting activities of R&D organizations in Korea are closely related to their respective situations. Some place an emphasis on producing S&T information simply for addressing S&T opportunities, while some focus on strategy formulation of their R&D activities. Somehow, this type of activities is the effort to adopt a proactive and rational approach to S&T activities including S&T resource allocation. Such activities have made a good deal of stimulation to other institutions including industries in Korea.

4 The Korean Delphi: details and major outcomes

The Delphi is a well-known method for technology forecasting; particularly for a long-range and large-scale forecasting at a time. [5] The nation-wide survey for technology forecasting employed basically a three-round Delphi. Three rounds were necessary because technological topics to be forecasted had to be selected with relevance to the Korean society. In the first round, thus, ideas of experts from the science and technology community of Korea were collected. It was thought that those topics, which have been forecasted in other countries, might not be appropriate for this country, because the technological capabilities of Korea as a developing country might significantly differ from those of advanced countries. Technological concerns and attentions of the Korean experts were thought to be influenced by factors unique to Korea.

The first round started with 25,000 experts. About 9,000 topics were finally collected from 5,000 experts and rearranged into 15 areas. Those areas were (1) information, electronics and communications technology, (2) production, (3) materials, (4) fine chemicals, (5) life science, (6) agriculture, forestry and fisheries, (7) medical care and health, (8) energy, (9) environment and safety, (10) minerals and water resources, (11) urbanization and construction, (12) transportation, (13) marine science and earth science, (14) astronomy and space, and (15) ultra technology.

At the same time, a technology foresight committee was organized for the overall decision making and 12 sub-committees for the arranged areas of technologies.

9 A more comprehensive discussion is provided in Shin. [6] The survey was performed between September 1993 and August 1994. It was managed by twelve committees composed of 91 specialists from industry (19), academia (48) and other organizations (25). [8]
Activities of the committees were mainly focusing on selecting the topics to be forecasted out of those 9,000 topics, and reviewing the verbal descriptions, in detail, of each topic. The committees selected 1,127 topics, which were manageable for the survey. Basically, all such activities at the first round were related to dealing with "what to forecast" and "who forecast".

Table 2: Technological topics by area and stage of innovation

<table>
<thead>
<tr>
<th>Area</th>
<th>Elucidation</th>
<th>Development</th>
<th>Practical Use</th>
<th>Widespread Use</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Information, electronics &amp; communications</td>
<td>4</td>
<td>56</td>
<td>56</td>
<td>9</td>
<td>125</td>
</tr>
<tr>
<td>2. Production</td>
<td>1</td>
<td>69</td>
<td>35</td>
<td>10</td>
<td>115</td>
</tr>
<tr>
<td>3. Materials</td>
<td>2</td>
<td>66</td>
<td>57</td>
<td>6</td>
<td>131</td>
</tr>
<tr>
<td>4. Fine chemicals</td>
<td>3</td>
<td>40</td>
<td>7</td>
<td>1</td>
<td>51</td>
</tr>
<tr>
<td>5. Life science</td>
<td>21</td>
<td>51</td>
<td>17</td>
<td>3</td>
<td>92</td>
</tr>
<tr>
<td>6. Agriculture, fishery &amp; forestry</td>
<td>16</td>
<td>33</td>
<td>28</td>
<td>6</td>
<td>83</td>
</tr>
<tr>
<td>7. Medical care &amp; health</td>
<td>33</td>
<td>52</td>
<td>27</td>
<td>5</td>
<td>117</td>
</tr>
<tr>
<td>8. Energy</td>
<td>1</td>
<td>39</td>
<td>36</td>
<td>11</td>
<td>87</td>
</tr>
<tr>
<td>9. Environment &amp; safety</td>
<td>9</td>
<td>48</td>
<td>22</td>
<td>6</td>
<td>85</td>
</tr>
<tr>
<td>10. Minerals &amp; water resources</td>
<td>6</td>
<td>25</td>
<td>17</td>
<td>2</td>
<td>50</td>
</tr>
<tr>
<td>11. Urbanization &amp; construction</td>
<td>3</td>
<td>36</td>
<td>17</td>
<td>6</td>
<td>62</td>
</tr>
<tr>
<td>12. Transportation</td>
<td>0</td>
<td>39</td>
<td>34</td>
<td>7</td>
<td>80</td>
</tr>
<tr>
<td>13. Marine science &amp; earth science</td>
<td>8</td>
<td>24</td>
<td>12</td>
<td>2</td>
<td>46</td>
</tr>
<tr>
<td>14. Astronomy &amp; space</td>
<td>0</td>
<td>11</td>
<td>13</td>
<td>0</td>
<td>24</td>
</tr>
<tr>
<td>15. Ultra technologies</td>
<td>1</td>
<td>7</td>
<td>15</td>
<td>3</td>
<td>26</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>108</strong></td>
<td><strong>596</strong></td>
<td><strong>393</strong></td>
<td><strong>77</strong></td>
<td><strong>1174</strong></td>
</tr>
</tbody>
</table>

Note: Figures are the number of topics
Source: Shin, Park, Jung & Kim. [3]

At the second and third rounds, the survey started with about 5,000 experts and ended up with about 1,200 experts. Out of them, about 54 % of the experts worked for universities; about 30 % for the public sector including NPRIs and about 16 % for industry. Such a distribution of experts over the professional sectors is a good reflection of the distribution of R&D manpower in Korea. On the other hand,

---

10 As some respondents handed in several questionnaires, at the end 2,297 questionnaires were available. [8]
more than 60% of those experts had experiences in their field for more than 10
years, and more than 80% hold Ph.D degree.

From the Delphi results, the forecasted time of realization of each topic was obtained as the median
year of the inter-quartile range. The distribution of cumulative number of topics for both Korea and
the world leader is shown in Figure 1. It is clear that the Korean innovation system is behind the
world leaders some years.

Figure 1: The Korean development scenario in S&T as compared to the world leaders.

An important indication for the convergence of experts’ opinions is the dispersion of the forecast
time which is measured by the distance between the upper and the lower quartiles of the estimations.
If the distance is relatively longer, then the experts are judging on the time scale in disagreement.
About 56% of all topics show less than 5 years between the upper and the lower estimates, therein
15% less than three years. Only three topics are at variance by more than 11 years. [3]

The private sector was greatly influenced by the first Korean Delphi. Large-scale firms have paid
greater attention to it, since their R&D investment keeps increasing. For example, the Korea Electric
and Power Corporation (KEPCO) in 1995 carried out an own Delphi for its long-term R&D
planning in cooperation with STEPI. About 400 topics in the area of electricity and new energy
sources were dealt with for the next 30 years. The Samsung and LG companies among others
established an own team for technology forecasting within their R&D management. Reportedly, the
major task is an overall surveillance of S&T opportunities and formulation of S&T strategies.
Recently, Samsung carried out a technology foresight study consulting the Japanese Mitsubishi
Research Institute. In this exercise, market forecasts were taken into account in conjunction with
technology forecasting, using Delphi, statistical analysis and documentation of available information
in combination.
However, as technology forecasting was firstly known to the Korean public by the Delphi survey, it is not yet accepted in general practice by many R&D organizations, particularly small ones - mainly due to the high cost and lack of experts available. Technology forecasting using other methods than Delphi has been hardly exercised and reported. Thus, in Korea, diversification of studies using various methods should be considered for the future.

5 Korean trajectories towards S&T development

In this section, an attempt is made to analyze Korea’s S&T development paths empirically. Based on the estimated time of realization of Delphi topics, it appears to be possible, with several assumptions, to draw a formal estimate for the future path of science and technology development. In general, the development trajectory of an individual technology can be represented by mapping technical parameters or functional capabilities onto the time scale. For example, the development path of the semiconductor can be denoted by the curve of the degree of integration or speed of data processing along with the time axis.

However, at the national level, catching-up in S&T might be defined in a different way. The S&T development of a country implies the increase in the country’s capability of creation, application and deployment of S&T knowledge. It will be influenced by S&T inputs primarily. However, no systematic relation is known linking S&T inputs to outputs.[7] When an attempt is made to measure S&T development, therefore, it is arguable whether S&T inputs or outputs should be employed. In any case, if a country is able to acquire technologies over time, the S&T assets of the country will be accumulated, in return contributing to the country’s S&T progress. Thus, it could be said that the cumulative number of technologies acquired in any innovation stage by a country over time represents the S&T development path at the national level, reflecting the aggregation of progress in individual technologies.
To obtain S&T development paths, the followings are assumed:

(1) A Stationary general frame continues over the next 20 years. That is, we assume no drastic changes in the Korean society to occur such as the South-North Korean unification, major natural disasters, etc.

(2) The 1174 topics presented in the Delphi survey are regarded as the technologies needed for S&T development in Korea. It can be said that more technologies will be needed in the course of time, but at the time of forecasting, we take the technologies as suggested by the Delphi respondents, upon which the expected time path can be drawn out.

(3) An imaginary world leader country is presumed so that Korea’s current position can be compared with the world leader’s. Such a world leader country is in fact a combination of several countries most advanced in science and technology.

(4) Since the forecasted time estimates are distributed mostly around 2005, outliers beyond 2011 are discarded in estimation of the S&T development path.

(5) The S&T development path is approximated linearly.

Under these assumptions, it is possible to estimate the paths of science and technology development statistically, using the Delphi experts’ opinions on the expected realization time. Since social impacts of the topics differ upon their realization, however, it does not imply that such S&T development is directly related to social well-being or economic competitiveness of the country concerned; but they may move into the same direction. On the other hand, since such paths do not take account of additional technologies newly emerging in the future, it will be therefore desirable to include them in future analysis by regularly undertaking the Delphi survey.

The S&T development paths can differ by area. The result of regressing the cumulative number of topics realized on the time axis are given in Table 3. Then, the slope of the estimated linear curve represents the speed or rate of change of S&T. The greater the slope is, the faster is the development of science and technology in the country. The slope of the curve can be influenced by S&T policies, such as R&D investment, qualified scientist and engineer, knowledge transfer mechanism, efficiency of the national innovation system, and others.

---

11 We checked logistic, S-shape and growth curves which did, however, not yield better statistical fits.
Table 3: Slopes of S&T development paths

<table>
<thead>
<tr>
<th>Area</th>
<th>Korea</th>
<th>World leader</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Areas</td>
<td>105.4 (18.6)</td>
<td>87.3 (10.5)</td>
</tr>
<tr>
<td>1. Information, electronics &amp; communications</td>
<td>11.1 (11.0)</td>
<td>7.8 (5.0)</td>
</tr>
<tr>
<td>2. Production</td>
<td>10.5 (7.2)</td>
<td>11.4 (4.7)</td>
</tr>
<tr>
<td>3. Materials</td>
<td>15.0 (10.5)</td>
<td>15.2 (5.0)</td>
</tr>
<tr>
<td>4. Fine chemicals</td>
<td>5.3 (11.6)</td>
<td>8.4 (8.0)</td>
</tr>
<tr>
<td>5. Life science</td>
<td>7.5 (7.9)</td>
<td>7.7 (13.8)</td>
</tr>
<tr>
<td>6. Agriculture, fishery &amp; forestry</td>
<td>7.3 (16.9)</td>
<td>10.3 (10.9)</td>
</tr>
<tr>
<td>7. Medical care &amp; health</td>
<td>11.5 (18.3)</td>
<td>10.9 (12.2)</td>
</tr>
<tr>
<td>8. Energy</td>
<td>8.6 (12.1)</td>
<td>6.4 (7.4)</td>
</tr>
<tr>
<td>9. Environment &amp; safety</td>
<td>7.9 (11.4)</td>
<td>8.6 (7.5)</td>
</tr>
<tr>
<td>10. Minerals &amp; water resources</td>
<td>4.5 (9.5)</td>
<td>5.3 (5.5)</td>
</tr>
<tr>
<td>11. Urbanization, construction &amp; civil engineering</td>
<td>5.2 (8.0)</td>
<td>6.9 (6.4)</td>
</tr>
<tr>
<td>12. Transportation</td>
<td>6.4 (8.9)</td>
<td>8.4 (9.7)</td>
</tr>
<tr>
<td>13. Marine &amp; earth science</td>
<td>4.3 (12.3)</td>
<td>6.1 (9.2)</td>
</tr>
<tr>
<td>14. Astronomy &amp; space</td>
<td>2.0 (11.5)</td>
<td>0.9 (7.6)</td>
</tr>
<tr>
<td>15. Ultra technologies</td>
<td>2.5 (14.0)</td>
<td>3.7 (9.3)</td>
</tr>
</tbody>
</table>

It is shown in Table 3 that Korea’s S&T development moves a little faster in all areas relative to the world leader, catching up by about one year in 15 years. The path slopes of Korea and the world leader are 105.4 and 87.3, respectively, implying that, by 2010, about 105 topics, on the average, would be realized per year in Korea, while about 87 topics in the world leader. Yet, successes set in earlier in the leading countries and by the year 2000 already 741 topics are realized whereas in Korea the number is only 138.

It is also shown, by area, that Korea is catching up fast with the synthetic world leader country in the areas of information, electronics and communications; energy; medical care & health; and astronomy. In particular, Korea (slope 11.1) in the area of information, electronics & communications is forecasted to be much more dynamic than the world leaders (7.8). Although Korea’s dynamics in the area of astronomy is greater than the world leader’s, more than half of the topics are already realized in advanced countries. Therefore, Korea’s catching up must be faster by simply transferring and implementing advanced technologies from the world leader.

But most of other areas fall significantly behind, such areas of production; materials; fine chemicals; life science; agriculture, fisheries & forestry; environment & safety; minerals & water resources; urbanization and construction; transportation; marine & earth science; and ultra

---

12 Figures are estimation results of the equation $NT_i = a_0 + a_1T + e$, (i = Korea, World leader), where NT and T denote the cumulative number of technologies and time, respectively. Figures in parentheses are t values. The regressions are all significant.
technologies. It is noted that Korea in the area of production keeps falling behind the world leader, although this area is related to the competitiveness of Korean industries.

An immediate policy implication from the results is whether Korea takes a balanced or an imbalanced development strategy. That is, with the limited resources, Korea might pursue strategically a few areas with more S&T investment, to catch up the world leader in those areas quickly. In this case, a careful assessment of each area should be made for more resource allocation, and consequently imbalance between the areas will widen increasingly. In the other case, Korea might pursue a S&T development which is well balanced over various areas. In this case, Korea should make more investment in the areas falling behind the world leader country.

8 South-east Asian trajectories towards science and technology development

South-east Asian countries have long histories with each country showing distinctive characteristics of its own. With the exception of Thailand, all countries in the region have gone through periods of colonization, and all have developed a strong sense of cultural identity. [9] With the exception of a few countries, the region has a very high and sustained economic growth of around 8% per year. This economic success cannot hide that the science and technology achievements are still peripheral by world standards. While there has not been any foresight exercise in south-east Asia on the scale seen in Japan, Europe or Korea, it is nevertheless possible to report on earlier attempts to shape the future of the national innovation system of these countries and to anticipate the future role of innovation in south-east Asian societies.

In the believe that knowledge generated elsewhere in the world can be applied for economic and social benefit, very little basic research is done in the region. South-east Asian countries tend to perform better in applied science and technology areas than in basic science. Yet, we witness an unwillingness of the private sector to invest in technology development. Still a large number of students are on scholarships overseas and the governments in the region try to bring back their skilled staff from abroad by a number of incentives. [9] It can generally be regarded as a problem that technology development is largely pursued in a non-business environment. What is the responsibility of the market forces in industrialized countries is considered a government task in most south-east Asian countries having economic and social development plans which typically look forward five years. When these are formulated some elements of short-time foresight on major science and technology components are embarked upon. Malaysia Singapore and Thailand, in addition, have articulated "visions".

Let us briefly have a look at selected countries. Recently in Thailand a study of future technologies has been undertaken. [10] 400 scientists and engineers were asked to assess the likely future importance of various technologies by the Delphi method. The time of realization, possible
constraints and other typical questions were raised. The technology areas chosen for the survey comprised basic technology, biotechnology, biomedical technology, metals and materials, transport, energy & environment and electronics & computer technology (software and hardware). In the questionnaire, economic benefits and welfare criteria for Thailand were broken down into five categories: farmers income and agro-industrial development, the economic value of plants, animals and microbes, the competitiveness on the technology level of industries, the emphasis for shifting labor-intensive to knowledge-intensive industries and people’s access to, and utilization of, information and technology. This seems to be a very specific operationalization of national, social and economic progress.

The results and conclusion from this Delphi survey, first of its kind in Thailand, will not be elaborated here as a number of identified technologies are quite similar to those expected to be of importance for developed countries. Although we noted that the five criteria to define economic and social progress were specifically designed for Thailand, and hence it could be expected that the findings of the study are equally specific, it seems from the results that the technologies that will be important for Thailand are about the same ones that are important for industrialized countries. This suggests, as Yuthavong [9] concludes, that "global competition within the technology areas is likely to intensify as the developing countries upgrade their capabilities".

The most serious obstacles found in the Thai foresight survey relate to the lack of well-qualified and high-potential personnel in science and technology, to good planning procedures in S&T as well as on efficient organization with good entrepreneurial innovation management for R&D, among others.[11] What concerns the next future, the Thai government is likely to invest a budget to the APEC center for technology foresight over the years 1998 to 2000 in order to conduct a feasibility study. This center is likely to be set-up in Thailand at the Chiang Mai university which performed the first Thai Delphi study.

In the Philippines, a technology forecasting committee was created in 1995 which is composed of policy makers, representatives from national scientific and economic authorities, academia and the private sector. The committee used the panel approach but also considered to employ the Delphi method. [12] However, as Delphi involves iteration of expert opinion, synthesis and feed-back, due to insufficient time and mainly because the attempt was the first technology foresight access in the country until now the outcome of this thinking stage is not known.

Likewise, in Indonesia a technology foresight project was implemented by a national agency. The project covers technology topics in eleven fields and employs the usual Delphi method with variations. In some areas investigated there was only a single survey round and also the brainstorming technique was effectively used in some cases before going into the second round and having the respondents work on a list of priority topics previously selected. This project is midway toward its scheduled completion when this article was written. A number of difficulties in collecting responses are already apparent and present a challenge towards successful implementation of the project as initially envisioned. One of those problems is that the pool of available experts is heavily concentrated in government R&D institutions and universities - a phenomenon likely to be found in other developing countries as well (see above). Among the highly rated topics of investigation are
items such as the development of electric train technology for mass transportation and the development of a model for energy planning that would observe the social, economic and environmental aspects.[13] Other topics concern natural-gas fueled motor vehicles and industrial core generation technology. All these topics are less ambitious than in industrial countries but finely tuned towards the needs of Indonesia. In the future, Indonesia is likely to support the above mentioned APEC center for technology foresight and to share the Indonesian experience of conducting the first technology foresight activity with other developing nations.

In 1994, China conducted a technology foresight exercise to select key technologies essential to national development. Reportedly, the technology foresight has played a very important role in S&T decision making at the national level. Likewise Chinese Taipei has been utilizing technology foresight methodologies to identify major strategies for S&T development in different stages.

7 South African trajectories towards S&T developments

South Africa is reorienting its national science and technology and innovation system drastically. Since recent years the apartheid system was abandoned which triggered off many new activities. The National Research and Technology Audit (NRTA) is a major government initiative to assess the strength and weaknesses of South Africa’s present scientific and technological base and its capacity to respond to the opportunities and risks the nation will face in the future. The audit is the responsibility of the Department of Arts, Culture, Science and Technology (DACST) which has requested the Foundation for Research Development to manage the audit. A central part of the audit is scoping the future trends that are likely to impact on the South African economy, environment and society over the next five to 15 years, against which the strength and weaknesses of the present science and technology system may be judged.

A national foresight project is running in South Africa at the time when this article was written.[14] The foresight team is based at the DACST but staff from the Council for Scientific and Industrial Research (CSIR) is participating looking particularly at methodological instruments, for instance scenario development.

The foresight project has been divided into twelve socio-economic sectors. Working groups are now being established in each of this sectors in a similar way as in the UK foresight program. As in Britain, a co-nomination technique is used to establish the list of respondants. When adopted, this groups will take the work to a foreseen completion at the end of 1998. The methodologies employed will include scenario development both looking at the possible futures for the South African S&T system and at individual sector scenarios and some sort of opinion survey. If this will take the form of a modified Delphi for South African conditions, was not decided at the end of 1997.
At the same time at the CSIR foresighting processes to fit a knowledge-based institution are going on. The CSIR 2020 foresight exercise was initiated in mid 1997 with the objectives to incorporate long-term perspectives into the business planning process and to identify and monitor trends in science and technology. Also the establishment of a culture of future thinking within the organization is aimed at. This process is scheduled to run annually by foresight champions in each of the CSIR’s divisions. The methodologies adopted include tools such as Delphi surveys, scenario development, co-nomination, trend analysis and others to various degrees.

8 Latin American trajectories towards S&T development

In December 1996, representatives of Latin American countries (Argentina, Bolivia, Brazil, Chile, Mexico, Venezuela and Puerto Rico) met in Santa Cruz de la Sierra, Bolivia, to discuss foresight activities and cooperations in foresight. The meeting was initiated and organized by the United Nations Industrial Development Organization (UNIDO). Representatives from European countries (Germany, Italy, the Netherlands, United Kingdom) and Japan were invited to present their experiences. There had been already smaller foresight activities in Latin America, especially in Brazil, but they are regarded as insufficient.

As a result of the meeting, an agenda was set up which describes the volition of Latin America countries to do foresight activities with different approaches. A core group with representatives from Argentina, Bolivia, Brazil, Mexico and Venezuela met in Madrid twice and elaborated a framework on foresight. This framework is supposed to be the basis of a project document which was just finished, when this contribution was written.

The project shall follow the framework, i.e.

- promote the foresight concept,
- provide training and technical assistance to foresight practitioners,
- give practical experience in the form of two or three multi-country studies, and
- set up a virtual technology foresight center.

The project will be supported by the National Science and Technology Councils in Brazil, Chile, Colombia, Uruguay and Venezuela as well as the United Nations Educational, Scientific and Cultural Organization (UNESCO) and ANEP in Spain. Some other science and technology councils still need to be convinced.

13 We are grateful to Professor Ben Martin, SPRU, for providing information to us, he obtained from Marissa Moore from the CSIR.
Separately, a publication is in preparation which would provide guidelines for developing countries to help them decide for and undertake technology foresight studies as an input to policy-making and the formulation of technology strategies on the firm’s level. Technology foresight in Latin American countries will in general focus on technology and products that meet the specific needs of the region and that can be produced and applied in the different countries.

9 Discussions

In this article we discuss technology foresight activities in Korea and in catching-up countries. The history of foresight activities in all these countries is not long, but we observe great activities now in various areas, in particular in Korea. At the Korean government level, S&T activities are well diversified, which may cause a serious overlap in S&T investment and mislead resource allocation. As S&T investment has been rapidly increasing, more efficient and effective R&D management skill is required more than ever before. The individual R&D organizations primarily emphasize priority setting through foresight activities, which is not enough to avoid misallocation of resources at the national level. In a diversified system, any foresight activity should place greater emphasis on the concerted action by a lead agency. The most influential ministry, MOST, has showed some successful exercises along this line.

In Korea a first Delphi survey was carried out to provide more extensive information on topics with wide-ranging consensus of the society. Emphasis of the Korean Delphi is on decision information, so that the post-foresight phase of planning did not follow. It has drawn a good deal of attention by the public and private organizations. Formal foresight studies other than with the Delphi method have been rarely exercised so far. As the way to formulate S&T strategies might differ from organization to organization, various methods should continue to be employed and tested.

A new interpretation of the results of the Korean Delphi is provided in order to explore the expected paths of S&T development in Korea benchmarked by a synthetic world leader country. Thus, from regression analysis of the time scale of topics realized in Korea versus leading industrialized countries we conclude that Korea’s S&T development sets in later but then more dynamically, catching-up about one year in the next 15 or so years. The areas of catching-up versus falling behind differ considerably. Such an analysis should be regularly undertaken in order to include new trends not being in the forefront now. The estimated paths might be regularly revised with updated data derived from repeated Delphis.

In matters of S&T foresight, Korea has a well-contrived national strategy: in Item 4 of the Advancement of Science and Technology Law, revised in 1991, it is required that a S&T foresight survey for the mid-long term shall be conducted every five years.[8] Yet, there may arise the need to extend the foresight period from 20 years to 30 years so that long-term topics can also be covered. It is expected that a second comprehensive foresight activity will be triggered by March 1998. Pre-survey research is already under way.
In south-east Asia, foresight has not yet been developed on the Japanese or Korean level. Yet, some countries are conducting or have just concluded formal foresight studies sometimes using modified Delphi methodology. They are engaged in economic and social development plans with typically a five year perspective. Some countries have articulated long-term visions with major S&T components. The topics of foresight are highly tuned to national bottlenecks but nevertheless indicate that global competition in technology will likely increase when these countries upgrade their S&T capabilities.

In South Africa, a national foresight activity is currently running to reshape the countries S&T system after apartheid has been abandoned. At the same time, major national S&T organizations are embarking on annually repeated in-house foresight activities.

Also in Latin America interest in foresight is growing. However, running a formal foresight study is a costly and time-consuming endeavor that absorbs valuable human resources. Most likely this group of countries is trying to learn from studies made by other countries and will slowly perform first own steps. Observing other countries and putting emphasis on understanding the implications of foresight activities for S&T restructuring can also lead to a well-prepared future strategy.

References


{10} Personal communication of one of the authors (H.G.) with S. Vanichseni (Chulalongkorn University), C. Sripaipan (NSTDA) and Y. Mukdapitak (Ministry of Science, Technology and Environment, Thailand) in Karlsruhe, October, 17, 1997. See also: National Science and Technology Development Agency and Chiang Mai University, Important Future. Technologies for Thailand, (in Thai), NSTDA, Bangkok, 1996.


{13} Sutrasno, T. et al., Indonesian Technology Foresight and Regional Technology Specialization, in APEC, MSTE, NSTDA (eds), *Technology Foresight*, NSTDA, Bangkok, 2nd ed., 1997, pp. 81-86.

{14} Personal communications during two visits of members of the foresight team at the institute of one of the authors (H.G.) in 1996 and 1997.