ROLE OF TECHNOLOGY BAROMETER IN ASSESSING PAST AND FUTURE DEVELOPMENT OF NATIONAL INNOVATION SYSTEM

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**Summary**

Along with increasing significance of innovation in socio-economic development grows the need to utilize future-oriented knowledge in innovation policy-making. Technology foresight and roadmap exercises support the planning and priority-setting of R&D and have become an indispensable element of policy-making. Besides technological development decision-makers need all-inclusive knowledge of future developments of society, economy and impacts of science and technology. When the worldwide competition is increasingly about the attractiveness of innovation systems, this knowledge is particularly important in performance comparisons to other economies.

The technology barometer in Finland is developed for measuring the techno-scientific state and development level of the nation as well as for making related comparative analysis to other nations. One driver behind the establishment of technology barometer is in a growing attention of international performance comparisons of innovation systems. In international performance comparisons Finland improved the position especially since the late 1990s and reached leading nations in early 2000s. Comparisons raised a lot of interest, debate and also critical discussion of the reliability of the ways, data and methodologies used in these exercises. For example, comparisons based on composite indicators are based on past data and give backward looking perspective, not visions and perspectives of future development. In The Finnish Association of Graduate Engineers (TEK) this discussion led to a decision to develop an own comparative exercise which, in addition to indicators based comparative exercise, includes also inquiry to relevant national actors on their views and visions of the future development.

Technology barometer is a compilation of data of how favorable and competitive Finnish innovation environment is now and in the future. The future is history-dependent and technology barometer, while consisting of a survey of future-oriented knowledge and indicator based study

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of past development, both following by and large the same structure, permits the linking of past and future in the analysis. Barometer consists of indicator based performance comparison of the national innovation system to selected nations and the second consists of the barometer, i.e. a survey of future visions and attitudes of key interest groups including politicians, industries, R&D community and the younger citizens. The theoretical background of technology barometer is based on the studies of the dynamic evolution of various development stages and models of a modern society. After the industrialized development societies are moving towards information society, then towards knowledge society and towards a knowledge-value society, complying with the principles of sustainable development. The indicators of technology barometer are structured in correspondence with the different development stages of a modern society.

Technology barometer has been completed three times (2004, 2005, 2007). A wide interest and active discussion that emerged after publishing each barometer proves that a social interest and order for such a barometer exists. The article discusses the background of technology barometer, its structure, the content and accomplishment and results of barometer, the impacts of barometer on national discussion, and finally draws conclusions and gives future perspectives of technology barometer. Technology barometer is an initiative of The Finnish Association of Graduate Engineers (TEK) and is accomplished in collaboration with VTT Innovation Studies.
1 Introduction

A growing number of different international comparison systems of the performance of nations have emerged within a decade or so. The role of benchmarking comparisons has become increasingly important in the era of globalization when competition is not only between multinational and other enterprises but also between economies and innovation systems. Performance comparisons are based on a number of indicators, composite indicators or survey studies providing comparisons in wide range of fields like economy, society, education, innovation system or sustainable development. Although useful in benchmarking of country performances, indicators, if poorly constructed, can have even misleading policy messages (Nardo et al. 2005; Freudenberg 2003). For example composite indicators illustrate complex and sometimes even elusive issues and they often seem easier to interpret by the general public than finding a common trends among many separate indicators. Accordingly composite indicators must be seen as starting points for initiating discussion and attracting public interest (ibid.).

Finland has improved her position among developed nations according to several international performance comparisons since the latter part of 1990s, and in early 2000s reached a position among leading nations for example according to competitiveness reports of IMD and World Economic Forum (WEF). Although Finnish policy-makers, industrial community, scientists and citizens have followed international comparisons and related discussion with great interest, there has been a national controversy regarding the problems and reliability of international performance comparisons. The criticism is related on the ways, data and methodologies used in comparisons. For example, one problem of comparisons based on composite indicators is that they give a backward looking “mirror” perspective, i.e. they are based only on past data, and not on examination of future visions. Gradually this critical discussion led The Finnish Association of Graduate Engineers (TEK) in decision to develop an own national comparative exercise. Since the beginning TEK planned to that the exercise will include both a comparative study of reference countries, based on indicators of past development, as well as future oriented survey exploring future visions of relevant national actors like industries, policy-makers and politicians, research community and future generations i.e. young citizens.

The Finnish Association of Graduate Engineers (TEK) developed technology barometer in collaboration with VTT Innovation Studies during 2002-2003. The first barometer has been published in 2004 and it has been repeated twice in 2005 and 2007. The plan is to publish a barometer once in 2-3 years. The content of the barometer will be further developed in appropriate ways, however, without jeopardizing its nature as a barometer so that the comparison of indicators of latest exercise to those of previous ones remains possible.

2 Theoretical background and methodology

Technology barometer is a societal indicator instrument with a strong emphasis on the innovation environment. The instrument describes the long-term development of competencies and resembles economic barometers in its attempt to grasp future developments. The purpose of technology barometer is to give data of how favorable and competitive the Finnish innovation environment is now and in the future. The future development is history-dependent and accordingly future-oriented knowledge shall be properly interlinked to past development path. In technology barometer this challenge is solved by dividing the exercise firstly into a comparison of the performance Finnish innovation system with selected nations based on international...
indicators, and secondly, to a technology barometer based study of visions and attitudes of relevant national key actor and interest groups. Indicator-based country comparison reveals the points of intervention in policy-making. In addition, forward looking survey enquires and identifies possible areas for development activities in national innovation policy in the future. Both parts follow, by and large, the same structure allowing the linking of ex-post and ex-ante analyses.

It is important for composite indicators, or any indicator system in that case, to have a sound theoretical basis (e.g. Nardo et al. 2005, and Freudenberg 2003). Technology barometer is based on the studies of the dynamic evolution of various development stages of a modern society after the industrialized development stage, i.e. from an information society into a knowledge society and from that towards a knowledge-value society. At the same time, it also indicates how effectively the development in question complies with the principles of sustainable development. Instrument utilizes concepts developed by contemporary social scientists and innovation theorists, such as Bell (1976), Masuda (1980), Sakaiya (1991) and Castells (1996; 1997; 1998). Barometer data thus illustrate a transitional phase and provide an overall image of how far the developed nations have come in a journey towards a knowledge-value society. The indicators of technology barometer are structured correspondingly among different development stages of a modern society, from an information society into a knowledge society and from that towards a knowledge-value society, and to the society fulfilling the requirements of sustainable development (Figure 1).

Figure 1. Internal structure of Technology barometer.

In the information society, information production, processing, dissemination and exploitation play a central role. In the barometer, the definition of an information society is focused around the investments in human and intellectual capital. Corresponding indicators are: basic education and schooling and the skills and knowledge of the general public in a nation, and both private and public investments in research and development.

The knowledge society produces commodities of high knowledge value. Knowledge and expertise constitute the crucial element in production, with information and communication technologies comprehensively supporting interaction, the dissemination and exploitation of knowledge, plus the provision and accessibility of services. In technology barometer, the indicators of knowledge society assess the gearing of the human and intellectual capital
investments towards science and technology, the applications of information and communications technologies, and the outcomes of these investments as R&D productivity.

Knowledge-value society is an advanced form of both the information and the knowledge society. Innovation, technology development, economic regeneration, openness to new ideas, and their active exploitation, are all inherent elements contributing to the basic values and culture in the society. The indicators on knowledge-value society focus on entrepreneurship and venturing, innovation networking, and adaptations of innovative practices in a nation.

Moreover, barometer indicates how effectively the development in question complies with the principles of sustainable development. The indicators of societies fulfilling the requirements of sustainable development are social values, environmental responsibility and environmental systems.

In conclusion, indicator study of technology barometer comprises 12 sub-indicators providing an index-type key value indicating the state of technology at a given time. Developments which have already taken place are depicted in one element based on statistical data. The indicator-based data can be used for the generation of index figures to display the nations’ techno-scientific base and level of societal development in comparison with the reference group. The reference group used in the first three implementation rounds consisted of Denmark, Finland, Germany, Japan, the Netherlands, Sweden, UK and USA.

There is an on-going discussion of the merits of different techniques applied in indicator based comparisons and related construction of composite indicators (see Nardo et al. 2005). In technology barometer each partial area is measured by using a combined indicator in order to calculate an arithmetic average value of several statistical indicators' normalised values between -2 and +2. For example, techno-scientific competence includes the demographic group of people aged 25-64 with higher education qualifications, the share of new graduates in techno-scientific fields in the age group 20-29, the share of people aged 25-34 with a doctor’s degree in the same fields, the share of women among researchers, the share of middle-level and high-level technology fields in the labour force, the labour force share of competence-intensive services and researchers in the total labour force. The combined composite indicator determines Finland’s proportional rating in comparison to the reference group.

Besides indicator study, technology barometer includes forward looking survey of future expectations of relevant target groups. Survey is based on questionnaire directed to four relevant target groups, i.e. Members of the Finnish Association of Graduate Engineers TEK, young people studying at the senior secondary school level, political decision-makers and business decision-makers. The information obtained from survey is used to analyze and interpret the results of indicator-based comparisons in order to understand the nations’ actual state of techno-scientific development. Combining indicator study and future oriented survey into one instrument creates a unique platform for further analysis.

3 Results of technology barometer

3.1 Indicator based comparison

Statistical indicators collected from the eight countries through OECD and Eurostat allow for comparisons and benchmarking to be made among the reference group. The barometer is used
to calculate an overall ranking list for the countries analyzed. A closer look into the contents of the various sub-indicators provides interesting and useful information.

In the first three implementation rounds of technology barometer all reference group countries appear to have specific profiles of their own with strong characteristic features. When assessing societies by information society indicators the Nordic countries – particularly Finland and Sweden – excel (Figure 2). This is partly explained by vigorous investments in the development of intellectual capital. Widespread appreciation of research and technical development among the people, as clearly expressed in the questionnaire survey, ties in with this. Judging by the indicators of the next phases, knowledge value society, the Nordic countries retain their strong positions, albeit with a smaller margin, followed by UK.

![Figure 2. Proportional ratings of the reference group countries.](image)

A look into the knowledge-value society indicators opens up a significantly different picture. Here USA, Denmark and Netherlands grasp the lead while the previous leaders lose ground significantly. Achieving the objects of this type of society also appears to pay off in practice. Scoring well in this section correlates strongly with the country’s rating in widely used indicators of material wealth, such as GNP per capita, purchasing power, or unemployment rate. Openness and capability to exploit a wide range of expertise irrespective of its origin appear to
be major factors here. Despite the vast amount of interest in the Nordic innovation policy during the last decade, even this approach may have its pitfalls.

The significant mutual differences in the profiles of countries are definitely factors calling for analysis of the underlying causes. In this study Japan appears to be an anomaly which at least partly is due to the country’s unique social structure.

The first barometer was published in 2004. Having reached its third round of implementation it is now possible to see what type of development trends are currently in progress in addition to the key numbers of each individual study. Figure 3 below is a synthesizing presentation of the Finland’s position according to 2007 barometer (Lehtoranta et al. 2007).

![Figure 3. Positioning Finland in Technology barometer 2007: Figure 3 sets out Finland’s above-average or below-average rating in comparison to the reference group (the y axis), and whether any improvement or deterioration has taken place (the x axis) in comparison to the previous survey.](image)

The synthesis paints a picture of country’s progress in each indicator of two recent technology barometers. In Figure 3 the indicators depicting the country’s long-standing above-average and further strengthening position are located on the upper right. Among others, the depicted areas include the understanding of knowledge and knowledge management. The indicators depicting an above-average but possibly deteriorating position are located on the upper left. Proportionally, deterioration has taken place in the techno-scientific competence, for example. The indicators depicting below-average position of Finland are located below the centre line. The weakest partial area proved to be the exploitation of ICT. Compared to the previous surveys (Technology barometer 2004 and 2005), positive development was observed in entrepreneurship and openness to internationalism.

### 3.2 Survey study of future visions
Technology barometer instrument also includes a survey about people’s expectations regarding the future development trends. The questionnaire is addressed to four target groups, Members of the Finnish Association of Graduate Engineers TEK, young people studying at the senior secondary school level, political decision-makers, and business decision-makers.

The purpose of survey is to complement and diversify the results of the indicator study by allowing the mutual comparison of the four respondent groups’ views and results of indicator study obtained in 2005 and 2007. The enquiry was divided into four parts in accordance with the partial indicators: competence and knowledge generation, knowledge society development, innovative society and sustainable development. The first part sets out the respondent groups’ assessments concerning the techno-scientific competence prospects and young people’s interest in a number of professions. The second part depicts the respondent groups’ assessments of Finnish research activities, the prevailing state of technology development and various societal institutions, which have an impact on research and on societal development in general. The third part examines innovative societies, and related indicators are the level of investment, entrepreneurial activity and the impact of technology development on the quality of life. The fourth part in the survey sets out assessments of sustainable development focusing on environmental threats, the state of the environment, and action taken by the authorities.

The 2007 survey had, among others, the following results. According to the results, the Finnish politicians are consistently more optimistic than professional engineers or company executives about the country’s techno-economic development. This has raised certain worried reactions in the media after the barometer’s publication. Assessments of the younger citizens clearly point out that in the future science and technology will be increasingly followed through means of interactive, instantly updated electronic media. The positive news here is that these areas continue to attract young people. However, the role of user-produced content in the media will increase. In the theme of education a number of significant questions arise, like the idea of including interactive and mobile media skills to science education curriculum at the elementary level.

3.3 Synthesizing discussion
Technology barometer 2007 accentuated three cross-cutting themes: the changing role of knowledge-intensive work, innovations and business, and education structures. The first extensive societal issue relates to the role of knowledge-intensive work in Finnish society, and to the new aspects introduced into this role in particular. The second theme of discussion is more comprehensive and concerns innovation and business activities. As the results indicate, the identification of innovation is not a straightforward process for the businesses involved. Unfolding the definition of innovation and trans-illuminating its meaning and significance at the company level could help businesses identify the various phases of the innovation process, so as to be able to covert ideas into products and market them with increasing efficiency. Identification requires competence development, in basic technologies and business thinking alike, so as to generate product concepts with increasing initiative and courage. The third societal viewpoint is more comprehensive and relates to education. Finland is successful in basic education and this was also indicated in the results. However, new kinds of challenges were also emerging in the questionnaire, as was indicated in the need for the skills in critical interactive media reading.
4 Conclusions

Technology barometer has proven to be capable of casting additional light on bottlenecks and problem areas within the innovation environment. It provides a vast amount of processed and organized information for further analysis, and it can be used as an aid for making long-term decisions concerning technology, innovation and education. Each of three barometer rounds and the media coverage that has followed them have generated vivid national discussion of the strengths and weaknesses as well as of the future directions of the Finnish economy and innovation system. Accordingly, a social interest and order for such a barometer clearly exists. Section 4.1 draws conclusions of the experiences of technology barometer as an instrument for innovation policy-making, and Section 4.2 discusses further development of the barometer in the future.

4.1 Barometer as an instrument for policy-making

One of the strategic aims of technology barometer is to provide guidance on technologies and actions with maximum benefits for the society. In order to reach this aim it is essential to strengthen the links between foresight activities, policy development, and actual technological development. Political decision-making takes place in an environment characterized by ambiguity of problems and a multitude of conflicting interests, while technological development tends to be very mission-oriented. Technology barometer aims at a contribution to related national discussion.

From the policy-makers’ point of view there is a clear demand for an instrument providing well argued, sound, and tangible results to serve as the basis for informed action. On the other hand, scientific approach as such creates a set of boundary conditions in order to avoid compromising too much of the scientific validity of the concept. The processes for analyzing the collected data and synthesizing it into meaningful conclusions remain the key tasks in technology barometer exercises. These tasks are also under continuous refinement and tuning. Especially the latter task, i.e. provision of meaningful and useful conclusions, requires combination of scientifically generated explicit knowledge with implicit – or tacit – knowledge from the research group. Barometer instrument, being a combination of social scientific and econometric methods, calls for a high degree of methodological transparency as well as transparency of all the utilized data. Transparency is of paramount importance for retaining the attention of the target groups and for avoiding confusion among audience.

Despite these conflicting interests the barometer concept has proven to be capable of casting some light into the “black boxes” of innovation system by focusing decision-makers attention to core subjects, and has been received positively in the political arena. The instrument has become an established point of reference among cabinet members, parliamentarians and politicians. Wide interest in the barometer is indicated e.g. by numerous articles in newspapers and professional journals.

4.2 Further development

The plan is to publish Technology barometer at appropriate intervals of two or three years. The precise timing of barometer procedure depends on factors affecting the national economy and innovation system. For example, political changes and elections, and also transformations in national innovation policies could be triggers of the barometer exercise. The content of barometer will be further developed in appropriate ways, however, without jeopardizing its
nature as the barometer, meaning that the comparison of latest exercise with previous ones remains possible, allowing the identification of changes occurred in the course of time both in indicator study as well as in survey study.

Recent relatively radical changes of Finnish innovation policy are challenging also data basis and indicators on research and innovation, and will be taken into account in the development of the structure and content of next technology barometer. The scope of innovation policy will be changed strongly towards demand-oriented direction, meaning that stronger role is given for consumer and user aspects in innovation process, and this change will be promoted also by organizational changes in the public administration of innovation. Moreover, the scope of innovation in policy-making will be extended from technological innovation towards business innovations and different social innovations. This development naturally raises new research questions and needs new data and novel indicators to be included in the barometer. In Finland, the sectoral research system will be renewed underscoring four topics: regional and community structures and infrastructures, knowledge, labour and welfare, sustainable development, and security, again raising demands to indicators. The process of developing national strategic centres for science, technology and innovation is under way in the fields of future importance for society and businesses. Moreover, structural development of universities towards more management-oriented entities is under way. All these changes pose new challenges to indicator and survey studies of technology barometer. However, the further development of barometer to respond to the above mentioned challenges is already in process.

One interesting question is whether this type of barometer activities could be carried out as international collaborations in the future. Currently, the organizations responsible for these kinds of activities, e.g. WEF and IMD, are research institutes or university units and the European Union also produces several indicator and barometer type publications. This discussion could be concluded that at this stage it is best to “let all flowers bloom”. If so, a benchmarking between different efforts in the fields of interest could nevertheless be of benefit for all the barometer exercises.

What future development possibilities does the technology barometer instrument offer? To conclude, technology barometer is going to be developed towards an instrument that analyzes innovation systems as far-reaching socio-economic-technical complexes. Also, in order to respond to the systemic challenges of the innovation policy environment, there is a need to increase the proactive and future-oriented elements in the barometer. We argue that more future-oriented evaluative schemes and templates are needed in order to grasp and understand the wider systemic challenges of the innovation practices. One new approach to be integrated in the barometer structure could be the “foresighting impact assessment” (FIA) currently under development at VTT. This approach seeks to combine evaluative impact assessment, risk analysis and foresight approaches into an anticipatory methodology that could, in the principle, be applied in the study of different kinds of societal “objects”, such as national innovation system, regions, research programs or societal actors, like firms and public organizations.

References


THEME 4: FTA and equity: new approaches to governance