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The role of the technology barometer in assessing the performance of the national innovation system

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ABSTRACT

Along with increasing significance of innovation in socio-economic development grows the need to utilize future-oriented knowledge in innovation policy-making. Foresight and road-map exercises are aimed at supporting planning and priority-setting of R&D and have become indispensable elements 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 about the attractiveness of innovation systems, such knowledge is important for comparing the innovation performance of nations to other economies. Finland is among the countries improving her position in worldwide performance comparisons since the late 1990s and reached leading nations in early 2000s. This attainment raised national interest and critical debate of the reliability of the data basis and methodologies used in comparisons. In The Finnish Association of Graduate Engineers (TEK) this discussion led to a decision to develop an own comparative exercise together with VTT. In addition to performance analysis based on ex-post indicators the barometer includes the questionnaire of the views and visions of the future development by relevant national actors. The theoretical framework of the barometer is based on the evolution of economies from industrial development phase to sustainable knowledge society. The barometer has been undertaken in 2004, 2005 and 2007, and a wide interest and emerged discussion of barometer proves that a social interest and order exists for the barometer. The article presents the background, methodology and results of technology barometer, discusses its impacts on national discussion, and gives perspectives for the future development of barometer.

1. Introduction

A growing number of different international comparison systems of the economic and innovation performance of nations have emerged within a decade [2]. The role of performance 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. Comparisons are based on a number of different indicators, composite indicators or survey based studies providing comparisons in a 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 convey misleading policy messages [1,2]. For example composite indicators illustrate complex and sometimes even elusive issues and they often seem easier to interpret by the

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general public than finding a common trend among many separate indicators. Accordingly composite indicators must be seen as starting points for initiating discussion and attracting public interest [1,2].

Finland has improved her position among developed nations according to several international performance comparisons since the latter part of 1990s, and soon 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 growing national controversy regarding the reliability of international performance comparisons and challenges associated with their use for national policy purposes. The criticism is related to the ways data and methodologies are 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 and often outdated data, and not on examination of future development. Gradually this debate led in The Finnish Association of Graduate Engineers (TEK) to the decision to develop an own national performance comparison. Technology barometer was developed in order to measure the scientific, technological and socio-economic state and development level of the nation and for making related comparative analysis to other nations. From the start TEK included in the barometer both a comparative study of reference countries, based on indicators of past development, as well as a 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. Consequently the barometer gives both a compilation of ex-post data and strategic perspectives on how well the Finnish innovation environment is positioned now and how competitive it is assessed and expected to be in the future.

The Finnish Association of Graduate Engineers developed a technology barometer in collaboration with VTT Innovation Studies during 2002–2003. The first technology barometer was published in 2004 and since then that barometer has been repeated twice in 2005 and 2007 [3–7]. The plan is to publish a barometer once in every two to three years. The content of the technology barometer will be further developed in appropriate ways, however, without jeopardizing its comparative nature so that the comparison of indicators of latest exercise to those of previous barometers remains possible.

2. Theoretical framework 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, industrial and business barometers in its attempt to grasp future developments. The purpose of a technology barometer is to give data of how favorable and competitive the Finnish innovation environment is assessed to be now and in the future. The future development of the economy and innovation system will be in part derived from the path dependent historical context and accordingly future-oriented knowledge shall be properly interlinked to the past development path. In technology barometer this challenge is solved by dividing the exercise first into a comparison of the performance of the Finnish innovation system with selected nations on a basis of available international indicators, and second, to a technology barometer based on a survey study of the visions and attitudes of relevant national key actor and interest groups. Indicator-based country comparisons reveal the strengths, weaknesses and related possible areas for intervention and policy-making, whereas the forward-looking survey enquires and identifies possible areas for development activities in national innovation policy in the future. Both parts are structured in a similar way enabling the linking of ex-post and ex-ante analyses mutually when drawing conclusions and making interpretations and policy implications on the basis of the barometer results.

2.1. Theoretical framework

It is important for composite indicators, or any indicator system in that case, to have a sound theoretical and methodological basis [1,2]. 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. The technology barometer instrument utilizes the concepts developed by contemporary social scientists and innovation theorists, such as Bell [8], Masuda [9], Sakaiya [10] and Castells [11–13]. For example, the Japanese futurist Yoneji Masuda and the American sociologist Daniel Bell have stated that the essential dimensions of a new society would be seen in the emerging service economy, the role of theoretical knowledge, and technology development.

The theoretical framework of transitional phases of economies created by contemporary social scientists was widely accepted as the platform for constructing the barometer instrument. The data used by the barometer illustrate transitional phases and provide an overall image of how far the developed nations have come in a journey towards a knowledge-value society. The various economic development phases form a context incorporating the significant socio-economic changes and dynamics into the analysis. The framework enables the structural comparisons of entire economies, their individual industrial sectors, related R&D and innovation intensities, and respective socio-economic changes. Structural characteristics, dynamics and knowledge intensity differ essentially also among developed economies, and the entire economic systems or their sub-systems are in different development phases. Thereby the inclusion of transitional phases of economies to the comparative analyses of economic and innovation systems deepens the understanding of the long-term socio-economic changes and dynamics. Moreover, performance comparisons are often based on input data for developing innovation systems, like private and public R&D investments, albeit the most important data is related to outcomes and impacts of inputs, like embedding of ICT into private and public sectors and consequent productivity increase.

The theoretical framework of technology barometer is based on various economic development stages since the first barometer exercise in 2004. 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 the knowledge society stage towards a knowledge-value society and towards the society fulfilling the requirements of sustainable development. By indicating these various development stages of society, the technology barometer consists of four components, each containing three indicators (Fig. 1).

In the information society, information production, processing, dissemination and exploitation play a central role in all societal sectors. The central role of information is apparent in the economy, production, working life, education and schooling, etc. In the technology barometer, the definition of an information society is focused around the investments in human and intellectual capital, and 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 (R&D). These investments show how effectively the information society related objectives will be achieved.

In conjunction with the reform of the Finnish information society strategy, the knowledge society is defined as one where knowledge and competence constitute the foundation for education, and the crucial element in production, with information and communication technologies comprehensively supporting interaction, the dissemination and exploitation of knowledge between individuals, businesses and other communities, plus the provision and accessibility of services. The knowledge society produces commodities of high knowledge value. 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.

The knowledge-value society refers to an advanced form that has developed from an information society via a knowledge society, and where the central role is played by the understanding of knowledge and knowledge management. In the knowledge-value 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 of the society. The default is that the most successful innovators are those who can exploit various expert sources with optimum efficiency in problem-solving situations and implement their objectives in close collaboration with other businesses, universities and research institutes. The ultimate goal of innovation activities is to improve the nation's competitiveness so as to promote citizens' wellbeing. The indicators on knowledge-value society focus on entrepreneurship and venturing, innovation networking, and adaptations of innovative practices in a nation.

In addition to the three development phases of a modern society, technology barometer considers sustainable development as a fourth object of analysis, indicating 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. The technology barometer measures the objectives of sustainable development by three indicator entities, social cohesion in the society in question, environmental protection actions taken by businesses and authorities, and the actual state of the environment.

In conclusion, an indicator study of the technology barometer comprises 12 sub-indicators providing an index-type key value indicating the state of technology at a given time. The development of an appropriate content, scope and structure of the technology barometer, as described above, involved a series of expert panels of the TEK, VTT and innovation policy experts. After various considerations a composite structure was deemed to best serve the needs outlined initially.

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.

2.2. Computation techniques

There is an on-going discussion of the merits of different techniques applied in indicator-based comparisons and related construction of composite indicators [1]. Methodological issues need to be addressed transparently prior to the construction and use of

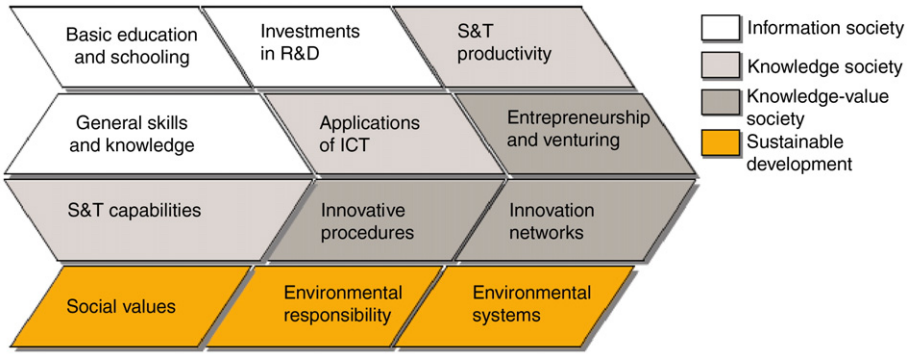

Fig. 1. Internal structure of technology barometer.

composite indicators to avoid data manipulation and misrepresentation [1]. OECD publications [1,2] give an overall state-of-the-art on principles and challenges in constructing composite indicators (Appendix A presents examples of composite indicators).

In the technology barometer the computational procedure is as follows. 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 (pages 17–19 in Technology barometer 2007, [7]) 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 aforementioned indicators are summarised in order to obtain a weighted index figure that shows the compared countries' ratings in terms of their techno-scientific competence. According to this index figure Finland rates as second after Sweden in Technology barometer 2007. In the same way other combined composite indicators determine Finland's proportional rating compared to the reference group countries in different areas of technology barometer (the content of Technology barometer 2007 is presented in Appendix B).

Besides the indicator-based comparative analysis, the technology barometer includes a forward-looking survey of future expectations of relevant target groups. The survey is based on a questionnaire directed to four relevant target groups, i.e. the 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 the survey is analyzed and interpret interpreted in parallel with the results of indicator-based comparisons. Together these analyses give an all-inclusive understanding of the present state and future perspectives of techno-scientific development of the nation. The combination of the indicator-based comparative study and the future-oriented survey into one instrument creates a unique platform for the further analyses of the economic and innovation performance of the nation.

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 barometer report the sub-indicators are weighted equally for each country. However, should one want to set different priorities to some sub-indicators, the fully transparent method does not prevent this in any way.

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 (Fig. 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 phase, knowledge society, the Nordic countries led by Sweden, retain their strong positions albeit with smaller margins, and followed by UK.

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. In this comparison phase Japan appears to be an anomaly which at least partly is due to the country's unique social structure. According to the indicators of sustainable development Sweden, Denmark and the Netherlands proved to be leading of the rated economies followed by Finland. The significant mutual differences in the profiles of compared countries are definitely calling for a detailed analysis of the underlying causes, and the barometer publications consist of a lot of complementary and comparative data and analysis of considered indicators.

The first barometer was published in 2004. Having reached its 3rd 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. Fig. 3 below is a synthesizing presentation of Finland's position according to the 2007 barometer and related change of position as compared to the barometer of 2005 [6,7].

The synthesis paints a picture of the country's progress in each indicator of two recent technology barometers. In Fig. 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 indicator studies (Technology barometer 2004 and 2005), positive development was observed in entrepreneurship and openness to internationalism.

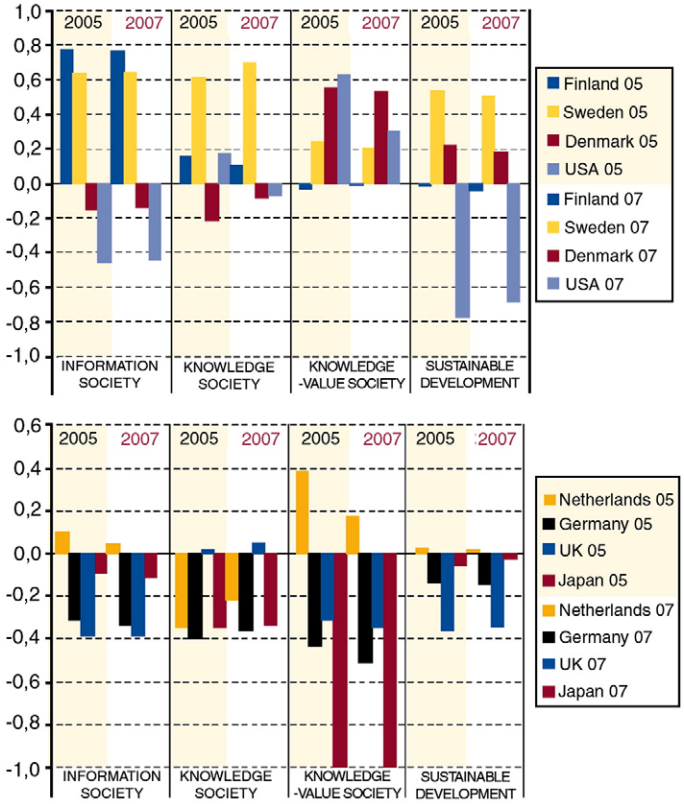

Fig. 2. Proportional ratings of the reference group countries.

3.2. Survey study of future visions

In addition to indicator-based comparison the technology barometer instrument 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 member group of TEK consists of the organisation's elected union representatives, the council, members of the board of trustees, and committee members, altogether 86 respondents. The second group is “Young People” for which a sample was gathered from six senior secondary schools located in different parts of Finland. The respondents, altogether

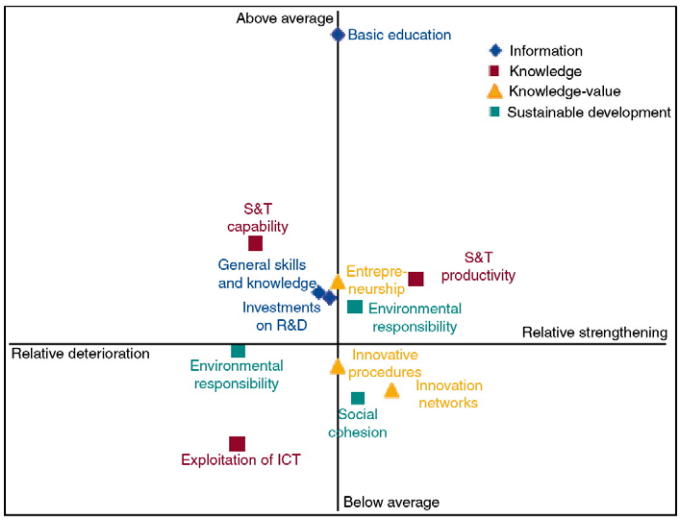

Fig. 3. Positioning Finland in technology barometer 2007: Figure sets out Finland's above-average or below-average rating in comparison to the reference group (the *y* axis), and whether any improvement or deterioration has taken place (the *x* axis) in comparison to the previous survey.

272, were 2nd year students sitting for their matriculation examination. The third group "Politicians" consists of members of the Finnish Parliament's Committee for the Future, provincial leaders, and the chairmen of the councils of the seven biggest towns. The fourth group of respondents, that of "Company Executives", was formed from one hundred of the largest Finnish companies measured in terms of their product development investments. Each group was presented with a set of questions tailored to highlight topics relevant to this specific audience. Some individual questions used in earlier studies, such as Eurostat surveys, were included in order to ensure consistency, and to allow later comparisons between different countries and surveys. The exact questions and formulations used can be found in the full barometer report [7].

The purpose of the survey is to cast light onto the respondents' valuations regarding technology, perception about current state of affairs, as well as their expectations for the foreseeable future. By doing this, the survey complements and diversifies 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. Standard statistical practices, such as the Mann–Whitney *U* test, were applied to analyze the results. 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.

Indicator-based information being backward looking by nature, the survey supplements the barometer by providing a forward-looking element to complete the overall view. This feature enabled by the composite structure has proven vitally important for both synthesis-making as well as drawing meaningful and relevant conclusions for policy-makers.

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

Each technology barometer consists of concluding discussions of certain topical issues arising from results of each barometer exercise. The selection and interpretations of these issues are made by the representatives of the TEK together with researchers from VTT. Accordingly technology barometer 2007 accentuated the following 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, due especially to the foreseeable challenges posed by globalization. The question considered are, for example, what will be the content of knowledge-intensive jobs retained by Finland in future and how should Finland direct and develop the role of knowledge-intensive work, educational and R&D investment on an extensive basis, in order to comply with the on-going changes in the economy from resource-based structures into competence-based ones.

The second theme of discussion is more comprehensive and concerns the future development of innovation and business activities. As the results of survey study 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 convert research based ideas into products and commercialize and market them with increasing efficiency. Identification of knowledge-based commercial ideas 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 even more comprehensive and relates to education. According to PISA comparisons Finland has been successful in basic education and this was also indicated in results of survey study. However, new kinds of challenges were also emerging in the questionnaire study, as indicated also by the need for the skills in critical interactive media reading. Especially young people's assessments point out the fact that, in the future, science and technology will be increasingly followed by means of interactive, instantly updated media such as the Internet and popular TV programmes of science and technology.

4. Conclusions

Despite the inevitable methodological challenges, the technology barometer has proven to be capable of casting additional light on bottlenecks and problem areas within the national innovation environment in Finland. Technology barometer provides a vast amount of processed and organized information for further analyses, and its results can be utilized as an aid and support for long-term decisions concerning science, technology, innovation and education. Each of the three barometer rounds, and especially the followed media discussion with a broad coverage, has generated a vivid national discussion of the strengths and weaknesses as well as the future directions of the Finnish economy and innovation system. Accordingly, there appears to be a strong demand,

most notably in terms of social needs and innovation policy interest, for the kinds of insights that the technology barometer exercise can deliver. Because the technology barometer is an initiative of The Finnish Association of Graduate Engineers (TEK), a professional and labour market organization with about 70,000 members, the possible impacts of results of barometer on government policy-making are rather indirect than direct ones.

Section 4.1 draws conclusions of the experiences and observable impacts of technology barometer as an instrument supporting innovation policy-making, and Section 4.2 discusses further development perspectives of the barometer in the future.

4.1. Results of barometer support innovation policy-making

One of the strategic aims of technology barometer exercise 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 between different stakeholders, 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. International comparative exercises, carried out such organizations as WEF, IMD or European Commission, are valuable for decision-makers in innovation policy, but furthermore the related national comparative examination gives additional and more detailed insights into the discussion of the future development of the national economy and innovation system.

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 among the key tasks in technology barometer exercises. These tasks are also under continuous refinement and fine-tuning. Especially the latter task, i.e. provision of meaningful and useful conclusions, requires a combination of scientifically generated explicit knowledge with implicit – or tacit – knowledge from the research group. The technology barometer instrument, which is a combination of social and economic scientific methods, calls for a high transparency of the methods used 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. Accordingly the three rounds executed have been an important lesson for the authors of barometer, and the publication of the last barometer is assessed to well fulfill transparency requirements of the stakeholders.

Despite the somewhat different premises of these stakeholder groups 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 barometer instrument has become an established point of reference among cabinet members, parliamentarians and politicians. Wide interest in the technology barometer is indicated e.g. by numerous articles in newspapers and professional journals.

However, merely drawing the attention of decision-makers is not sufficient for transforming vaguely expressed visions into concrete actions. Implementing change and guiding desired actions through the decision-making chain requires sound analysis based on quantifiable data that is presented in an understandable format. In addition to raising awareness, an instrument of this type may thus have a strong operational role in fostering the necessary decisions and providing the necessary facilities for the decisions in order to become materialized. Despite the political nature of these decision-making processes, the experience gained so far from barometer clearly indicates that the instrument providing this kind of qualifications may influence and have an impact on strategic policy-making all the way up to the highest levels in the decision-making processes. The feedback and requests from policy-makers for further information regarding the results of the barometer indicate that there is a call for means of bringing the expertise of the techno-scientific community to the use and utilization of political decision-makers. This is a clear encouragement to continue working on the metrics necessary for exemplifying the implications of innovation policy on the society. Therefore the wish presented above, i.e. the strategic aim of barometer is to provide guidance with maximum benefits for the society, may not be unrealistic.

4.2. Further development

The plan is to accomplish and publish technology barometer at appropriate intervals of two or three years. The precise timing of barometer procedure depends moreover on different 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 new barometer exercise. The content of barometer will be further developed in appropriate ways, however, without jeopardizing its nature as *a 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 data basis and indicators of research and innovation, and will be taken into account also in the further development of the structure and content of technology barometer. The scope of innovation policy will be changed strongly towards demand-oriented direction, meaning that the more important role in policy will be given for consumer and user aspects in innovation process. 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 merely towards business innovations and behavioural, organizational 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 of government administrations will be renewed, underscoring the following four topics: regional and community structures and infrastructures; knowledge, labour and welfare; sustainable development; and security, again raising demands for

indicators. Moreover, the process of developing Finnish national strategic centres for science, technology and innovation is under way in the technology fields with future importance for businesses and the society. In addition, structural development of Finnish universities towards more management-oriented entities is under way. All these changes pose new challenges to indicator and survey studies of technology barometer. The further development of barometer to respond to the above mentioned challenges is already in process. Monitoring the implementation of the recently published National Innovation Strategy will be one of the new features to be built into the next barometer rounds, again without sacrificing comparability to the earlier results.

Development of comprehensive indicators is time-consuming requiring a fair amount of resources as well as a widespread contact network within the society. One interesting question is whether this type of barometer activities could be carried out as an international collaboration exercise in the future. Currently, the organizations responsible for these kinds of activities, e.g. WEF and IMD, are research institutes or university units. Also, the European Commission produces several indicator and barometer type scoreboards and publications. With regard to the development of international comparisons the conclusions for the moment could be that at this stage it is important to "let all flowers bloom" in this field. 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? Technology barometer is going to be developed towards an instrument that analyzes innovation systems as far-reaching socio-economic–technical complexes. In order to respond to the systemic challenges of the innovation policy environment, there is also a need to increase the proactive and future-oriented elements in technology barometer. 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 in the future can be the future-oriented concept of impact assessment which is currently under the development at VTT. This approach seeks to combine evaluative ex-ante impact assessment, risk analysis, and foresight approach into one anticipatory methodological concept of strategic policy intelligence. In principle, this concept could be applied in the study of different kinds of societal objects and objectives, related to national innovation system, regions, research programmes or societal actors, engaging private enterprises and public organizations.

Appendix A. Examples of composite indicators

Source: JRC (2002) and compilation by OECD.

Area/name of composite indicator
Economy
Composite of Leading Indicators (OECD)
OECD International Regulation Database (OECD)
Economic Freedom of the World Index (Economic Freedom Network)
Economic Sentiment Indicator (EC)
Internal Market Index (EC)
Business Climate Indicator (EC)
Environment
Environmental Sustainability Index (World Economic Forum)
Wellbeing Index (Prescott-Allen)
Sustainable Development Index (UN)
Synthetic Environmental Indices (Isla M.)
Eco-indicator 99 (pre consultants)
Concern about environmental problems (Parker)
Index of Environmental Friendliness (Puolamaa)
Environmental Policy Performance Index (Adriaanse)
Globalization
Global Competitiveness Report (World Economic Forum)
Transnationality Index (UNCTAD)
Globalization Index (A.T. Kearny)
Globalization Index (World Markets Research Centre)
Society
Human Development Index (UN)
Corruption Perceptions Index (Transparency International)
Overall Health Attainment (WHO)
National Health Care Systems Performance (King's Fund)
Relative Intensity of Regional Problems (EC)
Employment Index (Storrie and Bjurek)
Innovation/technology
Summary Innovation Index (EC)
Networked Readiness Index (CID)
National Innovation Capacity Index (Porter and Stern)
Investment in Knowledge-based Economy (EC)
Performance in Knowledge-based Economy (EC)
Technology Achievement Index (UN)
General Indicator of Science and Technology (NISTEP)
Information and Communications Technologies Index (Fagerberg)
Success of Software Process Improvement (Emam)

Appendix B. Technology barometer 2007—Technology instrument for measuring citizens' attitudes and the nation's orientation towards a knowledge-based society

1. Introduction
2. Key results
   - 2.1. Barometer structure
   - 2.2. Key results
   - 2.3. Discussion
3. Indicators
   - 3.1. Competence and knowledge generation
     - 3.1.1. Basic education and schooling
     - 3.1.2. General education and competence
     - 3.1.3. Techno-scientific competence
   - 3.2. Knowledge society development
     - 3.2.1. Investment in research and product development
     - 3.2.2. Information and communication technologies
       - ICT expenditure
       - The use of information and communication technologies
       - eCommerce
     - 3.2.3. Application of new knowledge
   - 3.3. Innovative society
     - 3.3.1. Understanding of knowledge, knowledge management
     - 3.3.2. Entrepreneurship and economic regeneration
     - 3.3.3. Networking and openness in international activities
   - 3.4. Sustainable development
     - 3.4.1. Social cohesion
       - Health
       - Income distribution
       - Employment
       - Equality between sexes
     - 3.4.2. Environmental management
     - 3.4.3. State of the environment
       - Quality of air
       - Quality of water
       - Biological diversity
4. Survey, questionnaire results
   - 4.1. Material
   - 4.2. Competence and knowledge generation
     - 4.2.1. Prospects regarding techno-scientific competence
     - 4.2.2. Young people's interest in certain professions
   - 4.3. Knowledge society development
     - 4.3.1. Opinions regarding the standard of research and technical development in Finland
     - 4.3.2. Views concerning scientific-and-technical institutions and organizations
     - 4.3.3. Views regarding the roles of knowledge and technology in Finnish society
   - 4.4. Innovative society
     - 4.4.1. Investments and entrepreneurial activeness
     - 4.4.2. Potential effects of the development of technology on the quality of life
   - 4.5. Sustainable development
     - 4.5.1. Factors threatening the environment
     - 4.5.2. The state of the environment and the actions of the authorities

Appendices

- Content of the Technology barometer
- Key results
- Competence and knowledge development
- Knowledge society development
- Innovative society
- Sustainable development

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