Comparing Technological and Scientific Development: The Knowledge Society Development Barometer[1]

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The Knowledge Society Development Barometer is a globally unique instrument for measuring countries' technological and scientific expertise and development. Based on a ample literature on innovation and technological development, it consists of nine indicators providing index-type key values to measure the state of technology at a given moment. The barometer is based on models depicting society's development as it evolves from an information society via a knowledge society towards a knowledge-value society. Its data illustrate a transitional phase and give an overall impression of how far we have come in our journey to a knowledge-value society. Interestingly enough, reaching the knowledge-value society stage seems to correlate with a high GDP per capita and low unemployment rates.

Keywords: information society, knowledge society, knowledge-value society, R&D policy, innovation and technological change, competitiveness

Introduction

Technological development generates immense opportunities, but at the same time innovative activities are becoming more complex than ever as a result. Decisions on the direction technology and know-how are headed, prioritisations related to them and resource focusing are major issues for future competitiveness.

EU heads of state and Governments are determined to make the EU the most competitive and dynamic knowledge-based economy by 2010. This Lisbon strategy should be clear in all the EU activities. In introducing focal points for its activities, the Council's long-term strategy for 2004-2006 states that 'the Union is determined to pursue this overall strategy to make Europe the most competitive and dynamic knowledge-based economy, creating sustainable growth and new jobs and deeper economic and social solidarity while adequately considering the environmental aspects. The European Council, among others, has emphasised this point of view in its spring-term meetings by issuing a political statement and making concrete decisions in key areas.'

In economics, several established indicator sets or barometers have already proved useful. In this article, a similar indicator set is created on the techno-economic development of a given country. The Knowledge Society Development Barometer is based on models of the development of society that envision us evolving from an information society via a knowledge society towards a knowledge-value society. In an information society, investments in human and intellectual capital are the fundamental element, whereas in the knowledge society it is the fruits of the investments that matter. A

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knowledge-value society is an advanced form of an information society as well as a knowledge society. Innovation, technology development, economic regeneration, openness to new ideas and their active exploitation are all inherent elements of a society's basic values and culture.

The terminology around the information society, knowledge society development and so forth is generally extremely conceptual and symbolic. With the development of the barometer, one aim is to make this qualitative terminology more quantitative and descriptive.

Theoretical background: innovation and technological development in modern societies

New evidence and conclusions on the features of innovation across the economy as a whole have given rise in recent years to new theory and new approaches to policy. The theoretical background for these studies is diverse and includes literature from traditional microeconomic theory to modern systemic theory of innovation. In this section, I briefly review three relevant approaches to innovation and the innovation society.

First, I discuss the role of innovation in traditional micro- and macroeconomic theories. Then I briefly address the innovation studies approach, which draws on the Schumpeterian concept of how competition takes place. Competition is pre-eminently a differentiating process in which firms try to establish control over markets by developing new products and new processes. Lastly, I present some views on innovation and the innovative society from a political science and social science perspective. It should be noted though that most academics in the field consider information society literature to be a collection of intellectually rather loose popular writings with no real theoretical significance. Attitudes have gradually started to change, and major turning point has been Manuel Castells' *Information Age* trilogy in 1996-1998 and how it was received in the social science community. In his trilogy, Castells makes the first effort to systematically grasp the essential features of this fundamental societal transformation.

Innovation and technological development in traditional micro and macroeconomic theory

The production function approach is one of the foundations of mainstream neo-classical economics. The firm is viewed as a functional relationship between production inputs and outputs. As to innovation policy, the central concept in traditional microeconomic theory is the concept of market failure, as is thought to occur if markets fail to achieve the most efficient allocation of resources. In neo-classical models, innovation is presented as an exogenous element. The flow of innovations has weighty economic consequences, as it determines the results of production processes, but it is not viewed as being affected by them (Teece 1988). In these models, technologies arising from innovative activities are considered information-intensive goods (Arrow 1962).

Macroeconomic growth is historically determined by such factors as physical capital, labour and technical progress. In a neo-classical growth model by Solow (1956), technical progress is the most critical factor for a country's sustainable economic growth. However, traditional neo-classical growth models cannot explain why growth rates differ from one country to another, and why rich and poor countries can coexist in a world economy.

In recent years, ample literature on endogenous growth models (Romer 1986, Lucas 1988 and Rebelo 1991) has explored the idea that investment in knowledge and learning can affect long-run growth rates. Endogenous growth models make an effort to clarify the fundamental factors of growth rate divergence by describing the internal mechanism that endogenously determines technical progress as an engine of economic growth. It is noted for example that the productivity of human resources in future periods depends on current assignments (Lucas 1988, 17). In this literature, R&D investments are always central to growth. Consequently, the *level of the basic education and schooling* and the *skills and knowledge of the general public* in a nation and private and public *investments in research and development* are used as measures on the development barometer. The former is considered a proxy for human capital investments.

Innovation studies

Since the early 1980s, new industrial economics has moved away from the idea of perfect competition. It has done so by invoking the structure-conduct-performance approach: in addition to prices, other means of competition, i.e. marketing, R&D and so forth play a role in determining firm behaviour. Firms seek competitive advantages by continuously developing technologically differentiated products and changing processes to generate these products with competitive cost structures. In their seminal study, Nelson and Winter (1982) show that this competitive innovation process generates a plausible explanation for economic growth.

Let us select four important and related developments with respect to innovation and technological development: (1) the idea that technological change is *localised*,(2) the notion that innovation at the firm level is the outcome of a cumulative process, (3) the different incidence of factors determining the *appropriateness* of new technologies, and (4) dramatic value increase with each additional node or user, i.e. they exhibit *network externality.*

The idea that technological change may be *localised* is put forward in a theoretical article by Atkinson and Stiglitz (1969). They contend that a localised 'bulge' in the neo-classical industrial production function may represent technological change better than simply a uniform shift of the whole frontier. The location of the bulge essentially depends on the point where firms were initially producing, i.e. on their prior technological choices.

It can be argued that all large firms innovate. Moreover, multinational corporations tend to operate in more or less the same fashion wherever they are active. In scanning the local culture for innovation and technological development, the focus is on the *innovative procedures* of small and medium-sized companies.[2]

Another prominent feature of R&D is that it generates *cumulative* knowledge. Present-day knowledge capabilities may thus depend on past knowledge creation activities. This knowledge can be codified or tacit, but in either case it raises a barrier against new activity. In a relatively new type of research focused on a knowledge-based view of the firm, Cohen and Levinthal (1990) argue that absorptive capacity, i.e. a firm's ability to recognise the value of new external information and assimilate and apply it, is critical to its innovative capabilities.

The focus on the Knowledge Society Development Barometer moves from a nation's general skills and knowledge to its s*cience and technology capabilities.* Science and technology capabilities are considered an important component of competitiveness. This measure examines whether conditions external to the enterprise are more or less favourable to the production of new knowledge.

The third characteristic of innovation is that the knowledge incorporated in new technologies can be *appropriated* to varying degrees by the innovating enterprise. Since it is appropriation that allows for a temporary preemption of imitation and hence quasi-monopolistic rents and productivity, the appropriation of technological knowledge is essential to the innovative process. Although measuring *productivity in science and technology* is no simple task, several indicators have been developed. The development barometer includes patenting and scientific publications, the percentage of high- and medium high-tech industries and knowledge intensive services, the technology balance of payments and the percentage of new-to-market products.

Particularly in high technology, the level of interdependence between technologies is increasing. When a technology is adopted by firms and end users, the value of complementary technologies also increases, thus influencing the adoption decision of other users (Katz and Shapiro 1994, Arthur 1996). This results in the competition of various technological options and standards, and their diffusion throughout the population is affected by the installed base and the rate of adoption (Baptista 2001). In the case mentioned above, the good is said to exhibit *network externalities,* i.e. the higher the value of the good to an individual, the more people will use a similar good. I get back to this important issue in the discussion on knowledge-value society.

Concepts of information, knowledge and knowledge-value societ

There is currently no universally accepted concept of exactly what can or cannot be termed an information society. The information society is viewed as a successor to the industrial society. The term was introduced in the early 1970s by Yojeni Masuda, but similar concepts were discussed in the 1950s and 1960s. Harvard University's Daniel Bell was the first to put forward the concept of a post-industrial society in 1959, and in 1979, he renamed it the information society. Behind Bell's contribution was the discovery that between 1909 and 1949, in the non-agricultural sector growth rates, skills accounted for 87.5% of the growth, and labour and capital a mere 12.5%.

In the early 1990s the Institute of Information Studies, consisting of the Aspen Institute and other agencies in the USA, published an almanac for 1993-94 entitled *The Knowledge-based Economy: The Nature of the Information Age in the 21st Century.* The United Nations immediately endorsed the term and gave it a clearer definition in 1996. It defines a knowledge-based economy as an economy whose most important elements are the possession, control, production and utility of knowledge and intellectual resources.

A knowledge society develops on the foundation of science and technology achievements. The rapid development of computers and telecommunication networks has boosted the information expansion. Data and information are far more accessible now to everyone who is linked to information networks or knows how to access them (Soete and Ter Well 1999, 9). Indeed, one of the major impacts of the information and communication technologies (ICT) is the further acceleration of the innovation process. Though modern ICTs do not automate innovation activities, they do become an enabling technology.

Information and communication technologies currently constitute a prime focus of R&D in the industrialised nations. Close to 30% of all the public and private R&D budgets is devoted to them. The level of spending varies considerably however from one country to the next. The USA and Japan have a sizeable lead over European countries whose R&D budgets, although disparate, generally remain limited (Pouillot and Puissochet 2002). On the development barometer, three indicators are used to measure the *extent to which IC technologies are applied* in a nation.

The knowledge society produces commodities of high knowledge values. The values bear properties of high technique, high art, and high skill that vastly increase the value of products and services as compared with their production costs. Many customers are able to use them simultaneously in distant places and they do not wear out. Intellectual property including patents, brands, advertisements, services and consultancy plays a significant role.

The term 'knowledge-value society' was introduced by Taichi Sakaiya in a book he wrote in 1985. The term was defined as 'a society where the value of knowledge is the primary source of economic growth and corporate profits.'

The Japanese nation had devoted all its energy to becoming an industrialised society that mass-produced standardised goods. The school system was designed to produce highly patient and cooperative people with less originality and creativity, perfectly suited to work in standardised mass-production industries. The media and other information sources were centralised in Tokyo, and products manufactured to the same standards were distributed throughout the nation accompanied by identical information. As a result of this process, however, the knowledge-value revolution in Japan was delayed. This was because the nation had meticulously developed a government administrative organisation, industrial structure, financial system, employment practices, educational system and information environment that were appropriate for a standardised mass-production society (Sakaiya 2000).

In the knowledge-value society, creative labour is a major factor. The economy mainly includes intellectual enterprises, hi-tech parks where the entrepreneur is also the scientist. The society is characterised by a positively synergistic interaction of information, knowledge and affect. Leading companies develop holistic models of corporate cultures built upon shifting duties, team structures, and high levels of expedient personnel turnovers. The unit of analysis for innovation is not a product or technology, but a business concept (Hamel 2000). Business concept innovation, not only the technology that enables it, is the key to creating new wealth.

Today it is the rapidly growing small and new firms that provide employment growth. In the Netherlands between 1994 and 1998, 60% of the new jobs in the existing businesses were at just 8% of the rapidly growing firms. Similarly, in the USA some 350,000 firms created two-thirds of the jobs from 1993 to 1996. The *Global Entrepreneurial Monitor (GEM)* study (Reynolds et al. 2001) notes that the level of entrepreneurship positively correlates with GDP gains and that variation in the rate of entrepreneurship may account for as much as a third of the variation in economic growth. According to Bygrave (1998), the most significant strategic U.S. advantage is entrepreneurship.

On the development barometer, *entrepreneurship and venturing* is an important knowledge-value society measure. Entrepreneurship not only produces jobs, it stimulates the economy and binds society in weaker regions, it raises productivity and competitiveness and lowers consumer prices.

Innovation increasingly relies on the combination of various sources of knowledge and expertise. Cooperation with other firms and via public research can help accelerate the production and diffusion of new ideas. Globalisation is reflected in the relative importance of foreign sources in financing the business sector's R&D. Crucially, countries can try to attract foreign financing for R&D by being attractive as locations for direct high-tech foreign investments with sophisticated R&D activities that potentially create international knowledge spill-overs.

In a globalised world, successful firms, regardless of their size, are the ones that can tap into a global network and meet global production standards. Many analysts feel that locations will become irrelevant in a world of global input-factor arbitrage. Global networks enable industries to source labour, materials and supplies more efficiently while minimising their costs. The knowledge-value society is emerging in a context of globalisation, where it will thus always encounter stiff competition. However, cooperation will generate efficiency and mutual benefits. On the development barometer, the issues of globalisation, openness and internationalisation of R&D are covered in the *innovation networks and internationalisation of R&D* measure.

Barometer framework

Statistical indicators

The Knowledge Society Development Barometer is based on models that envision society as evolving from an information society via a knowledge society towards a knowledge-value society. The barometer data thus illustrate a transitional phase and present an overall picture of how far we have come in our journey towards a knowledge-value society.

In the information society, information production, processing, dissemination and exploitation play central roles. The knowledge society produces commodities of high knowledge values. Knowledge and expertise constitute crucial elements in production, with information and communication technologies comprehensively supporting the interaction, dissemination and exploitation of knowledge, plus the provision and accessibility of services.

A knowledge-value society is an advanced form of an information and knowledge society. Innovation, technology development, economic regeneration, openness to new ideas and their active exploitation are all inherent elements of the basic values and culture in the society. These three themes of the development barometer are presented in figure 1.

A reference group of eight countries is used, Finland, Sweden, Denmark, The Netherlands, Germany, the United Kingdom, Japan and the USA. The development barometer comprises nine measures that provide an index-type key value to measure the state of technology at a given moment. The results can be monitored and compared by conducting measurements at different moments. The measures are introduced in the theoretical background section of this article and described in greater detail in the subsequent sections.

To calculate the index values, the data are standardised, i.e. an average performance on the indicator results in the value of zero and only a very good or very bad performance results in values of over one or less than minus one. The measures are then aggregated to see how well each nation does as to the information society, knowledge society, knowledge-value society and sustainable development measures.

Figure 1 Three Themes of the Knowledge Society Development Barometer

Results

Information society

As is noted above, there is currently no universally accepted concept of exactly what can or cannot be termed information society. Following the endogenous growth literature, the definition of the information society focuses on investments in human and intellectual capital. In other words, the level is measured of the basic education, schooling, skills and knowledge of the general public in a nation and the private and public investments in research and development. The results are presented in figure 2.

The measure of human capital investments consists of two components. The first evaluates the level of basic education and schooling and the second the skills and competencies of the general public. *The level of basic education and schooling* is evaluated by the OECD's Programme for International Student Assessment (PISA). PISA measures reading, mathematical and scientific literacy on continuous scales. Japan and Finland score the highest on the PISA and Germany the lowest.

General skills and knowledge are measured by four indexes: three literacy skills from the International Adult Literacy Survey (IALS) and participation in life-long learning. IALS shows that rather than enlarging the pool of highly skilled workers, the tendency is to increase the skills of the already skilled. Sweden scores the highest on this indicator and the USA and the UK the lowest.

Investments in R&D are at the core of a knowledge-based economy because its dynamics and competitiveness depend primarily on the production, distribution and use of knowledge and information. However, R&D expenditure is only an input factor. It does not tell us anything about the efficiency of producing knowledge outputs, which is determined

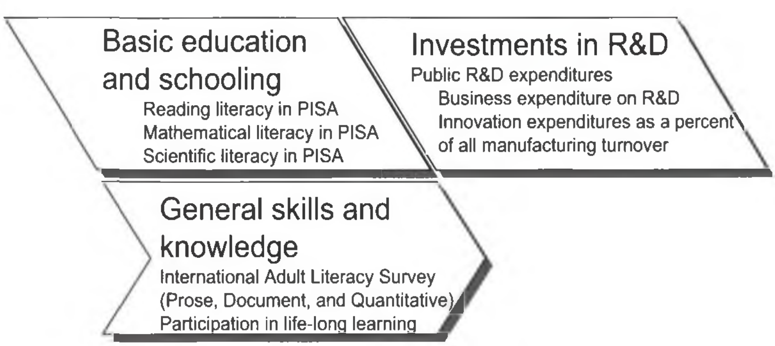

Figure 2 Information Society Measures: Information Production and Capabilities Development by Investments in Human Capital and Research and Development

Table 1 Information Society Measures

	Index	*Basic education and schooling*	*General skills and knowledge*	*Investment in R&D*
Finland	**0.78**	1.08	0.25	1.01
Sweden	**0.77**	−0.10	1.37	1.03
Denmark	**−0.24**	−0.74	0.38	−0.36
Netherlands	**−0.25**	n.a.	−0.01	−0.49
Germany	**−0.63**	−1.22	−0.57	−0.09
UK	**−0.41**	0.53	−0.76	−1.00
USA	**−0.42**	−0.69	−0.89	0.32
Japan	**0.33**	1.13	n.a.	−0.46

by the efficiency of the innovation system (research infrastructure, cooperation, interactions, capability to absorb external technology and so forth). In R&D expenditures, Sweden and Finland score the highest and the United Kingdom the lowest.

The aggregate information society measure consists of three components (see table 1). Finland and Sweden score the highest in investments in human resources and Germany the lowest.

Knowledge society

The knowledge society is an economy directed by knowledge where the generation and utilisation of knowledge play a prominent role in the process of producing wealth. The knowledge society measures assess the extent to which human and intellectual capital investments are geared towards science and technology, the use of information and communication technologies, and the outcomes of these investments. The results are presented in figure 3.

The measure of *science and technology capabilities* consists of a number of indicators. Finland and Sweden score the highest. Surprisingly, The Netherlands scores the lowest.

- A population with a college or university education is a general indicator of the supply of advanced skills.
- The number of new graduates in science and engineering is an indicator of the capacity to produce and the availability to the enterprise sector of the skills most necessary to produce, absorb and use new technology.
- New PhDs in science and technology represent the highly qualified output of the education system in disciplines of crucial importance to industry in this new economy.
- The participation of women in the production of knowledge is an important indicator

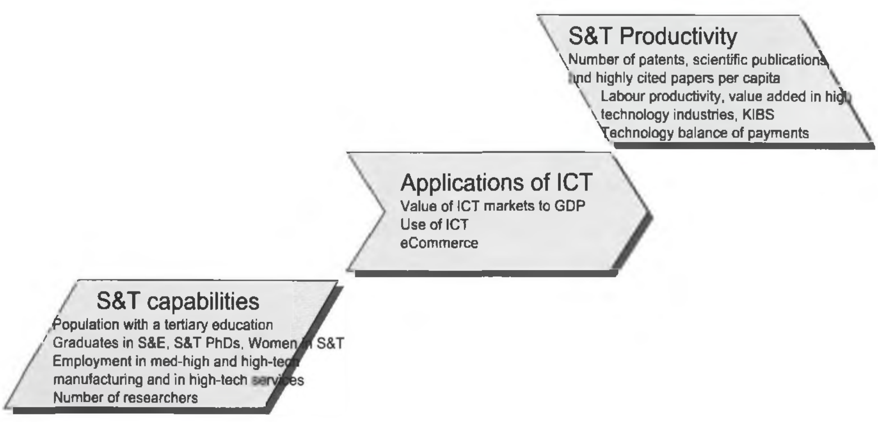

Figure 3 Knowledge Society Measures: An economy directed by knowledge where the generation and utilisation of knowledge is essential to the creation of wealth

of the extent to which the full potential of human resources is used in a society.

- The percentage of total employment in medium-high and high technology manufacturing sectors is an indicator of the percentage of economic activity in manufacturing sectors characterised by high levels of innovative activity.
- The high technology services provide services directly to consumers such as telecommunications and provide inputs to the innovative activities of other firms in all the sectors of the economy. High tech services, when properly used, can increase productivity in many economic sectors and support the diffusion of a range of innovations.
- The number of research scientists and engineers reflects the current use of human resources in R&D occupations. Research workers are responsible for producing knowledge and using it. They also transfer knowledge when they cooperate with other researchers in different institutions or countries and when they change professions or move from one sector to another.

Three indicators are used to measure the *extent to which IC technologies are applied* in a nation. The three indicators combine a number of sub-indicators, especially the use of ICT, which consists of ten sub-indicators. In this measure, the United States and Sweden score the highest and Germany the lowest.

- Calibrated by GDP, the total volume of ICT markets in the various countries gives a measure of ICT penetration in the economy and indirectly of progress towards the knowledge-based economy.
- A large number of sub-indicators are used to evaluate the use of IC technologies in a nation.[3] The Nordic countries score the highest and Japan the lowest.
- The indicator for eCommerce comprises four sub-indicators: Internet users who have purchased online, percentage of companies selling online, percentage of companies buying online, and number of secure servers.

Commercialisation and increasing competitiveness are reflected in emerging new activities and new products for the domestic and export markets. The *productivity in science and technology* is measured by several indicators. On this measure, the USA and Sweden score the highest and Japan, Denmark and the United Kingdom the lowest.

- An application for a patent indicates the production of new knowledge linked to an invention, and more importantly that this knowledge may have potential economic returns.
- The number of scientific publications indicator is very often used as a sign of the research capacity and growing knowledge pool of a country or a specific research community. Numbers of publications only tell us about quantity; quality is more closely associated with the indicator related to citation counts.
- Labour productivity is an indicator that measures the value added that is created by one unit of labour. It is associated with the relative percentage of activities in high and low productivity sectors. It also depends on the capacity to absorb new technology and the availability of highly qualified workers able to take advantage of the benefits of technological progress.
- Value-added is the best measure of manufacturing output, whereas other indicators such as total production can be biased by screwdriver plants with little value-added. In Europe, Sweden, Finland, and the UK have the highest percentage of high technology value-added. The results for Finland and Sweden are generated by the mushrooming ICT sector there. The UK benefits from aerospace and pharmaceuticals.
- The percentage of high- and medium high-tech industries indicates the strength of an economy in R&D-intensive activities and the capacity to transform scientific and technological knowledge into economic activity.
- The percentage of knowledge-intensive services in total economic output demonstrates the relative importance of knowledge-intensive activities and structural change towards a knowledge-based economy.
- The technology balance of payments indicator measures the importance of a country's receipts from exporting technical knowledge and services. It indicates a country's competitive position on the international knowledge market.

Table 2 Knowledge Society Measures

	Index	*S&T capabilities*	*Applications of ICT*	*S&T productivity*
Finland	**0.24**	0.95	−0.32	0.09
Sweden	**0.53**	0.58	0.54	0.47
Denmark	**−0.25**	−0.35	0.01	−0.41
Netherlands	**−0.36**	−1.05	−0.25	0.22
Germany	**−0.29**	−0.37	−0.50	−0.02
UK	**−0.10**	−0.01	0.13	−0.41
USA	**0.52**	0.26	0.75	0.56
Japan	**−0.26**	−0.05	−0.30	−0.42

- The new-to-market products indicator is a direct output measure of innovation that is not distorted by market speculation. The product must be new to the firm, which in many cases also includes innovations that are world firsts.

The aggregate measure of a nation's development towards a knowledge society is based on the three measures cited above. The results are presented in table 2. In the aggregate knowledge society measure, the USA scores the highest followed by Sweden and The Netherlands scores the lowest.

Knowledge-value society

The knowledge-value society measure focuses on entrepreneurship and venturing, innovation networking and adaptations of innovative practices. The results are presented in figure 4.

When measuring a country's *innovative procedures*, the focus is on the activities of small and medium-sized companies (SMEs). SMEs are fertile breeding grounds for new ideas and innovations, which is why supporting SMEs in their R&D activities has now become an important policy objective. Complex innovations, particularly in ICT, often depend on the ability to draw on various sources of information and knowledge or collaborate on the development of an innovation. The percentage of all the manufacturing SMEs with cooperation agreements on innovation activities is used as an indicator. This indicator is a proxy for the existence of a knowledge transfer between public research institutions and firms and among firms. The third indicator focuses on SMEs with in-house innovative activities that develop product or process innovations themselves or in combination with other firms. Denmark scores the highst on SMEs' innovative activities. The United Kingdom scores the lowest. No data is available on the USA and Japan.

The variation in entrepreneurial attitudes can be followed through to the point where many of the largest companies in the USA today are very young, while in Europe all the largest companies in 1998 were already large in 1960. This is clear from the measure of *entrepreneurship and venturing*. The USA and The Netherlands score the highest. Germany and Japan score the lowest.

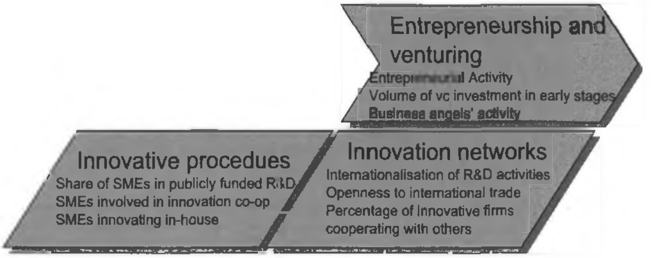

Figure 4 Knowledge-value Society Measures: Creativity, technological development, openness to new ideas and their proactive exploitation as driving forces of a networked society

- The Global Entrepreneurship Monitor (GEM) is a global initiative that explores links between entrepreneurship and economic growth. GEM produces data on nations' entrepreneurial potential, thus providing reference material for economic policy-makers interested in entrepreneurship.

The capital market functions imperfectly in financing new high tech and knowledge-intensive activities that are risky and uncertain. This weakness makes it necessary for new sources of finance and adequate institutional frameworks to be created for financing new, risky and promising opportunities.

- Although relatively small, the volume of venture capital available in the early stages plays a strategic role in financing innovation and thus supporting structural change towards a knowledge-based economy. Venture capital companies not only provide equity capital, they also provide managerial skills and competencies crucial to the success of firms at the early stages of their life cycle.
- The business angels' activity indicator measures the total number of deals done by business angel networks. Business angels are private informal investors that fund projects generally too small for venture capital institutions. They often also play a mentoring role.

Innovation networks and internationalisation of R&D are linked to strategic issues in the development of a dynamic knowledge production and absorption system. Countries can try to attract foreign R&D financing by being attractive as locations for high-tech foreign direct investments (FDIs) with sophisticated R&D activities that potentially create international knowledge spill-overs. Ever-increasing levels of trade and investment are only made possible by the substantial progress in recent years in opening economies to international competition. Recent research suggests that the value of market openness in terms of fostering innovation and stimulating improvements in competitiveness is at least as important, if not more so, than just access to international markets. On the innovation network measure, The Netherlands clearly scores the highest and Japan clearly the lowest.

- UNCTAD's Inward Foreign Direct Investment Performance Index ranks countries by the FDI they receive relative to their economic size, calculated as the ratio of the country's share in global FDI inflows to its share in global GDP.
- There are also sources of funds external to transnational corporations, raised by foreign affiliates in host countries and international capital markets. Expenditure on establishing, acquiring or expanding international production facilities is thus higher in value than the amount normally captured by FDI flows. Regardless of how it is financed, the capital base of international production is reflected in the value of assets of foreign affiliates.
- The internationalisation of business sector R&D activities is reflected in the increased role of foreign investments in knowledge creation and provides the potential for international knowledge spill-overs.
- Market openness gives consumers an opportunity to be exposed to new products and technologies that simply would not be available without international competition (Romer 1994). More open economies are able to absorb and benefit more rapidly from R&D activities elsewhere (Helpman 1997). Market openness pushes domestic companies to compete on the basis of innovation or be displaced by imitative lower-cost substitutes from abroad (Porter 1990, 1998).
- Innovation cooperation can have important effects on S&T productivity in firms by sharing (and thus reducing) the costs of R&D, while improving the quality of new products and shortening product life cycles.

The knowledge-value features of a society are measured by its adaptation of innovative procedures, level of entrepreneurship and venturing and the role innovation networks play. The aggregate results with respect to these three measures are presented in table 3. Here, The Netherlands scores the highest followed by Sweden and Japan scores the lowest.

From information society towards knowledge-value society

The development barometer shows that nations' techno-economic situations vary considerably. On the indicators related to the infor-

Table 3 Scores on Knowledge-value Society Measures

	Index	*Innovative procedures*	*Entrepreneurship and venturing*	*Innovation networks*
Finland	**−0.14**	−0.03	0.04	−0.43
Sweden	**0.41**	0.27	0.55	0.41
Denmark	**0.37**	1.29	−0.13	−0.05
Netherlands	**0.60**	−0.07	0.83	1.04
Germany	**−0.33**	−0.13	−0.69	−0.17
UK	**−0.15**	−0.72	−0.23	0.51
USA	**0.26**	n.a.	0.81	−0.29
Japan	**−0.80**	n.a.	−0.67	−0.93

mation society, Finland scores the highest. This is not very surprising, since Finland has been investing for some time in the creation and production of information. On the knowledge society measures on knowledge investments, Finland's position is distinctly lower and it is even below the average in the comparison group on the indicators on the knowledge-value society. This means Finland might do well to reconsider its national technology policy.

General trends in the nations' performance are presented in figure 5. Sweden scores the highest on all the measures and Germany and the United Kingdom generally score the lowest. The performance of The Netherlands, Denmark and the USA is especially interesting. With small inputs at the information society level, their entrepreneurship, networks and internationalisation enable the Dutch to place themselves at the top on the knowledge-value society level. The profile of the USA is somewhat similar. What is striking is that of the eight countries, The Netherlands, Denmark and the USA are the ones that have the highest GDP per capita (on purchasing power parity basis) and the lowest unemployment.

Discussion

The barometer raises an interesting question about the development of the knowledge society. It cannot just be a matter of the maturing

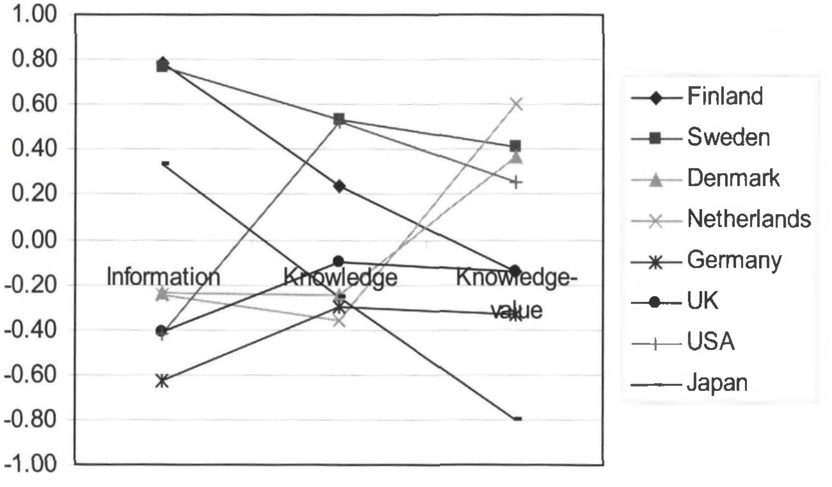

Figure 5 Sample Nations' performance on Information Society, Knowledge Society and Knowledge-value Society Measures

of investments in the creation of information. Denmark and the Netherlands bounce to the top of the knowledge-value society indicators from very moderate positions on the indicators for the preceding stages. Have these nations successfully used the results of technological development without an especially large input of their own in the development work, and if so, how have they managed that? On the other hand, Finland's shining results in the international competitiveness surveys do not show up as a rise in its standard of living. Is Finland's present innovation system based on a one-sided or overly narrow idea of the innovation process?

The barometer shows a clear correlation between the scores on the knowledge-value society measures and high GDP and low unemployment levels. In this respect, the outcome of Sweden is paradoxical. Why isn't the leader on almost all the information, knowledge and knowledge-value society measures the leader in GDP and employment? Indeed, Sweden has gone from being one of the richest countries in the world in terms of GDP per capita to a position below the OECD average.

Swedish investments in intellectual capital would be expected to translate into high technology exports and hopefully rapid economic growth for a highly export-dependent economy. But while R&D investments have soared, Swedish exports remain largely specialised in medium and low-technology products. There might be limited transformation pressure in the Swedish economy. The formation and growth rate of new high-technology firms are both low in Sweden (Rickne and Jacobsson 1999). None of the 50 largest Swedish corporations have been founded since 1970, and more than 60% were founded before the First World War.

Several explanations for this lack of entrepreneurship have been noted (cf. Johansson 2002): The tax system strongly favours the institutional ownership of firms and individual owners, business angels, venture capital and stock options are punished by double or triple taxation. Unemployment benefits are strongly linked to seniority in permanent employment. Labour market legislation tends to increase the transaction costs of hiring staff, putting a special burden on new and expanding firms. A very flat wage structure has lowered the wage premium on education – the percentage of youngsters entering college or university has decreased – while high taxation tends to lower the utilisation of the educated workforce.

The main objective of this trial implementation of the barometer has been to test the concept and practise carrying it out. Judging from the response and the results, there seems to be a permanent need for it in the field. In Finland, the objective is to use the barometer as an aid in making long-term steering decisions on developing technologies, expertise and resource allocation.

Notes

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2 In Europe, these are enterprises that have less than 250 employees and either have an annual turnover not exceeding ECU 40 million or an annual balance-sheet total not exceeding ECU 27 million, and conform to the criterion of independence. The Japanese define SMEs as companies with less than 300 employees.

3 Home Internet access, Internet use in the population, Cellular phone subscribers, Internet in schools, Workers who use computers for work, Internet dial-up access costs (residential), Internet dial-up access costs (business), ADSL prices, Home ADSL access, Availability of government services online.

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