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PRACTICAL GUIDE FOR ACTIVE NATIONAL POLICY MAKERS – WHAT SCIENCE AND TECHNOLOGY POLICY CAN AND CANNOT DO?

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Practical guide for active national policy makers
– What science and technology policy can and cannot do?

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Abstract: The aim of this report is to look at the role of science, technology and innovation policies from the perspective of the national policy process and to offer certain conclusions for the tasks related to the progress toward a knowledge-based society and economy in the European union. Three different national innovation systems (NIS) are presented on the basis of KNOGG country experiences: a country trying mainly to promote technology diffusion, a country intentionally developing national capacities to create, and a country relying on market forces without policy interventions. The most important difference between the NIS of the larger and smaller countries is the greater dependence on the external sources of knowledge and innovations in smaller countries. The realisation of the goals related to the establishment of the European Research Area (ERA) will open new opportunities but also create new challenges for the small countries.

Key words: science, technology and innovation, national innovation system, knowledge

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Tiivistelmä: Raportissa tarkastellaan KNOGG-maiden kansallisten tiede-, teknologia- ja innovaatiopolitiikkojen merkitystä edettäessä kohti osaamiseen perustuvaa yhteiskuntaa Euroopan unionissa. KNOGG-maiden kokemusten ja käytäntöjen pohjalta on tunnistettu kolme erilaista kansallista innovaatiojärjestelmää. Yhdessä nojaudutaan muualla tehtyihin innovaatioihin eli teknologian diffuusioon, toisessa keskitytään luomaan omia innovaatioita ja kolmannessa annetaan markkinoiden ohjata toimintaa. Pienten ja suurten maiden innovaatiojärjestelmien merkittävin ero on pienten maiden suurempi riippuvuus ulkoisista tiedon ja innovaatioiden lähteistä. Euroopan tutkimusalueelle (ERA) asetettujen tavoitteiden toteutuminen merkinnee suuria muutoksia pienille maille. Kehityksen myötä niille voi avautua mahdollisuuksia, mutta myös uhkia. KNOGG-maiden kokemuksia voisi käyttää hyväksi ERA:a toteutettaessa.

Asiasanat: tiede, teknologia ja innovaatiot, kansallinen innovaatiojärjestelmä, osaaminen

Foreword

Technological change and its contribution to economic growth has made many governments aware of the importance of the technological change and knowledge. The discussion about the role of science, technology and innovation policy has become, with targets of the Lisbon summit and the Barcelona meeting, increasingly important within the European Union and also in the coming new member countries.

This report is the fourth deliverable of the EU–financed research project "Knowledge, Growth and Globalisation – Science and Technology Policy as a Growth Factor in Smaller Economies" (KNOGG), which focuses on the experiences of small European countries. The KNOGG partners consists of research units from Finland, Greece, Hungary, Ireland, the Netherlands and Slovenia. The first report of the KNOGG project was published in the VATT-Research Reports series with the number 91, the second with the number 99 and the third with the number 100.

This survey looks through the role of science, technology and innovation policies from the point of view of the national policy process aiming to offer some conclusions on the way towards a knowledge-based society and economy in and as a part of the European union. Different national innovation systems of the KNOGG countries will be discussed as well as reflections of different small country policies on the European Research Area.

Helsinki, September 2003

Reino Hjerppe

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Executive summary

This report discusses the influence of the changes in domestic and international environment on science, technology and innovation (STI) policies in small countries. It deals with such important changes as the new trends in science, technology, globalisation and the main aspects of the transition to a knowledge based economy. The report contains an analytical overview of the main conclusions of earlier work packages of KNOGG and of the issues related to the progress toward an European Research Area from the perspective of national policies. The report is looking at the sources of success and failures in national STI policies including the relevance of the main indicators, and the issues of the management of knowledge. The last part of the report is dealing with the role of the public perceptions concerning R&D and innovations.

The most important difference between the national innovation systems of the larger and smaller countries is the rate of dependence on the external sources of knowledge and innovations. The processes of globalisation and regional integration have a much greater influence on the small countries. There are also other differences rooted in historical traditions and geopolitical situations.

The role of the market forces in the demand for research and development has increased markedly and there is a drive for greater efficiency and economic rationality is reshaping the role of science and making national science policies more pragmatic and market oriented.

An important question from the small country perspective is why some countries invest a larger proportion of their GDP in R&D than others. One explanation is based on the character of specialisation of the different countries. According to this view, countries which are specialised to high technology industries, i.e. to producing goods and services which are research intensive, need to invest more in R&D. This explanation disregards the fact that in order to develop a research intensive economy, the countries need sufficient research infrastructure with high investments in R&D and education. Another explanation is based on the size and character of the firms. Countries, which are the home of large international or transnational corporations are likely to have sufficient resources and R&D infrastructure. This explanation has particular importance in the smaller countries, like the Netherlands and Finland among the KNOGG participants. A third explanation to differences is based on the cultural tradition. A fourth explanation is focusing on the character of the innovation policies. The emphasis on imported technology through FDI may not stimulate national R&D investments. The absorptive capacities of the countries must be also taken into account.

Globalisation has a major influence on many aspects of STI. The European Union has become an important medium for promoting internationalisation of STI in Europe and transmitting global processes. Globalisation of STI implies important opportunities for the small countries also as a potential source of new knowledge. However, in a globalising knowledge system it is easy to become marginalised in the main flows of

knowledge. That implies new challenges and tasks for public policy. Instruments, which promote the inflow of new knowledge, like measures which upgrade the national R&D infrastructure, expand the national reservoir of highly skilled people, attract high technology research and production activities of the transnational corporations are particularly important for small countries.

FDI is an important mechanism to increase the knowledge base of small European countries. Small developed countries are squeezed between two developments. First, the growing complexity of new core technologies and limited resources impede the development of an extensive R&D infrastructure. So called national treasure R&D is hard to achieve in small countries. The other development is that competition in low and medium tech products is increasingly dominated by the Newly Industrialising Countries. At the same time technology is increasingly internationalised. The way out of this squeeze for small countries is to make optimal use of the internationalisation of R&D.

On the basis of the main characteristics, goals and instruments of STI policies in the KNOGG countries one may identify a few models for the governance of the national innovation system. The concrete goals of policies can be different in the framework of the models. One dimension of the strategies is related to the climbing of the countries on the ladder of the international technology system. The models of the STI policy processes are of course reflecting the national policy system, which influences the role of different actors and the character of their interactions.

In the first model, a small country is depending mainly on the external sources of innovation. The aim of the STI or RTD policy is to promote the transfer; adaptation, diffusion and development of technologies. With imported technologies the country is taking advantage of innovations developed in other countries. The strategy used in this model is in fact an open policy that attracts transnational companies. It may be necessary to create incentives to speed up investment, especially FDI. This is wise because new technology is usually embodied in new equipment, but also in new work practises imported by foreign investors – especially TNCs. There are a multiplicity of ways in which TNCs can enhance the innovation potential of the host country: they can make an important contribution to its research system through R&D spillovers; they can incubate high-tech spin-off companies; they can act as conduits for the transfer of codified and non-codified technology through human resource mobility and intensive-interaction with the indigenous sector; and they can stimulate the creation of networks of suppliers of high value-added products, components and services to supply foreign-owned industry. That kind of policy emphasises the business infrastructure (e.g. logistics), availability of educated and flexible labour force, and financial and fiscal incentives offered to investors. As examples of such policy one can mention Ireland, The Netherlands and Hungary.

In the second model, the country aims to develop national sources of innovations. That makes it necessary for the government to play a fundamental role in the STI process. The aim is to improve the absorptive capacities of the economy by intentionally developing a national innovation system, including advanced education system, high level research community and research laboratories, lots of R&D funding and intermediary institutions to bridge the gap between research and industry. Such a system promotes creation of original innovations, but at the same time it also improves the capacity to adopt and develop new technologies created elsewhere. The model can be risky for a small country since it requires large investments. It requires long term political commitment, too. Finland is an example of that kind of model.

In the third model, the market is playing a decisive role in the size, regress and patterns of STI. This is basically a Laissez faire policy since there is no rule for government intervention. It is based on the hope or assumption that the markets will take care of diffusion process. That, of course, may be the only alternative for a small country without sufficient resources to do anything.

There are a few main issue areas which must be taken into account in the future when knowledge-based growth is concerned. The future of the individuals on the path toward the knowledge based society depends to a great extent on the opportunities of obtaining knowledge. Only a learning society can “climb” higher on the ladder of knowledge. Equal opportunities must be offered by the society in obtaining knowledge. The gender aspects of these processes are particularly important. The example of the some of the KNOGG countries indicate that a social consensus on the importance of knowledge and technology is an important condition of success. This requires greater transparency in STI policies and effective participation of people in the democratic process. There are also many ethical issues involved, from the honesty of science to the honouring of public interests in application and marketing. International co-operation should be also developed such a way, that the interests of the smaller and weaker partners will be taken into account. The process of co-operation must be more effective in promoting the catching up of the lagging behind countries.

Contents

1. General introduction

The identification of the main issues is a fundamentally important stage of STI policy development. It includes the analysis of the national capabilities, the different contributing factors and also the emerging national, regional and global environment. This is an essential step before setting the science policy priorities programs. The framework for the elaboration of policies for the decisions on the tools of implementation, for the necessary institutional reforms and the participation in international co-operation regimes is the national system of innovations.[1] The concept of the “national innovation system” has been characterised and developed in details and also in historical perspective by Chris Freeman, but the expression was first used according to Freeman by Bengt-Ake Lundwall in his book in 1992.[2] Freeman argued that contrary to some works, which put the emphasis on globalisation in the context of innovation, the national and regional systems of innovations remained an essential domain of economic analysis. According to Freeman, while external factors, like international co-operation and actors, like the transnational corporations are of growing importance, the influence of the na-tional educational system, industrial relations, technical and scientific institutions, government policies, cultural traditions and many other national institutions and factors are fundamental.[3]

A National Innovation System (NIS) refers to the system of Knowledge Producers and Knowledge Users and to their interactions, together with the set of government policies and infrastructure that impinge on their activities. A healthy NIS enjoys a vigorous interaction between the education system, industrial base, development agencies and the financial system. This generates an environment which both encourages and supports companies to become ever more innovative.[4]

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[1] The concepts which are used in WP4 have a more or less general acceptance in the professional literature. Their definition, offered by the different authors and international organisations may somewhat differ. ”Science” is considered for example as a particularly broad area of human activities encompassing basic and applied activities, hypotheses and empirical observations. Science denotes “to know”.”Scientific research” is concerned with the acquisition of knowledge in accordance with systematised scientific method. Development, in the interaction with research is considered as the systematic use of knowledge and understanding gained from scientific research directed toward the production of useful things or methods. It its loose understanding the concept of “innovations” refers to all kind of new developments. The term technical innovation is used in particular, to indicate the introduction and application of new methods of production or the introduction of new products. The concept is also used for characterising minor or more important improvement in other areas of human activities. “Diffusion” includes two processes. One is the spread of knowledge about new products and processes, the other is the spread of new processes and products. Innovation must be clearly distinguished from the concept of “invention”. In the real life there is a complex relationship between inventions, innovations and the diffusion process. These interrelations are shaped by different social and economic factors, including the learning process.

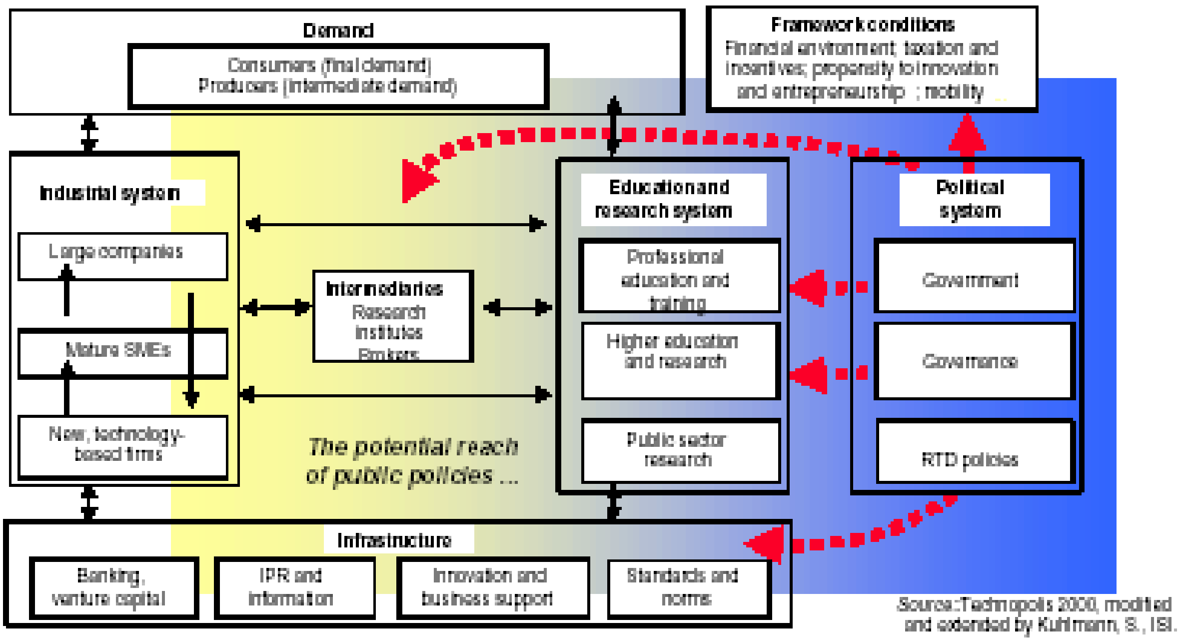
[2] Lundvall B-A (ed.) 1992: National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning. London, Pinter.

[3] Chris Freeman: The National System of Innovation in Historical Perspective. Cambridge Journal of Economics, 1995. 19.p.5.

[4] From the Irish national paper in WP4.

The NIS is typically depicted as shown in exhibit 1.[5]

Exhibit 1. National innovation system



Source: Arnold Erik, Kuhlman Stefan, van der Meulen Barend, *A singular council: Evaluation of the Research Council of Norway*, report to the Royal Norwegian Ministry of the Church, Education and Research Affairs, Brighton: Technopolis, 2001.

[5] Future directions of innovation policy in Europe, op. cit.

The NIS as thus portrayed as an interweaving of five subsystems:
Policy System: Government
Governance, RTD Policies

Education and Research System (Knowledge Base):
Higher Education & Research
Public Sector Research
Professional Education & Training

Enterprise System:
Large Firms
SMEs
NTBFs

Intermediary System:
Research Institutes
Private Consultants

Infrastructure System:
Business and Innovation Support
Standards/Norms e.g. IPR
Finance (Banking, Venture Capital)

Market:
Intermediate Demand: Producers
Final Demand: Consumers

The most important difference between the national innovation system of the larger and smaller countries is the greater dependence on the external sources of knowledge and innovations. The processes of globalisation and regional integration have a much greater influence on the small countries. There are also other, important mainly structural differences. There are differences rooted in historical traditions and geopolitical situations. The different policy models, or dimensions even in the KNOGG countries are in fact reflecting specific efforts aiming at the adaptation to different situations or the results of interacting social, economic and technical changes within the national economic space or in the international environment. The evolving international environment for all the countries, participating in the KNOGG project includes the progress toward a regional system of innovation in the framework of the European Union. The realisation of the goals related to the establishment of the European Research Area will imply radical changes. It may open new opportunities but may also create problems for the small countries. An all European infrastructure may stimulate more efficiently research and development promote diffusion. The co-ordination and harmonisation of national efforts may be resulting in a more efficient utilisation of the existing capabilities. The progress toward the creation of an "all-European" venture capital fund may help the entrepreneurs in the small countries etc.

Most of the detailed discussion of the policy issues related to the progress in ERA will be in WP5. In WP4 we are going to discuss those issues, which are more directly related to national policies. There are four very important dimensions of STI which cut across the national and the international framework of innovations: the intellectual, the economic, the political and the social. The intellectual dimension of science and technology deals with the creation and spread of knowledge.[6] It includes activities in research institutes, universities, firms and the work of individual researchers. The national scientific and technological capabilities are in the foundations of these dimension. The economic dimension treats science and technology as a means of attaining economic objectives of firms, countries and individuals. These can be achieved by using market forces or of the instruments of the governments. There can be the combinations of both. The political dimension sees science and technology as representative of a nations competitiveness, power and prestige in international context. It includes the public policy process and its institutions. In both the economic and political dimension, science and technology are a means to an end, which means that in a competitive world the focus is increasingly on the economic and political dimensions. The social dimension of knowledge is expressing the complex and difficult relations between STI and the perceptions, expectations and attitudes of the given societies. This dimension however is not just "theological". Science and technological development has become the major industry during the past century and will remain so in the 21st century, involving huge budgets and large numbers of employees. It is now a major productive force, in that the means of production and distribution (technology) have increasingly become an embodiment of scientific knowledge. Science has become a major generator of needs and the means to satisfy them including the quality of life, the ethical and other values and norms of societies. The "European" dimension of STI is in fact related to all the four dimensions and it is shaping the role of a united Europe in the future global system. There are of course different indicators for measuring the volume, the composition and the contribution of R&D to economic growth, the dynamic reciprocity among technology, economics, politics and culture cannot be measured in any tangible way. A thorough analysis can reveal however many aspects of these interactions and their dynamical, thus helping corporate and government policymakers choose appropriate policy responses. At the most comprehensive level, culture is also one of the factors shaping economic ideology. Culture helps to define what the acceptable and appropriate relationships between the state and the market are. Culture also affects styles of communication and negotiation that can facilitate or complicate problem solving. At corporate level, the corporate culture defines how the work of the firm gets one and affects attitudes toward corporate rivalry and co-operation, international copyrights and patent law. Management of key resources, like the financial, human and intellectual capital is also embedded incorporate culture. How firms value human and intellectual capital are

[6] Knowledge is a vague term without specific qualification of it. The tasks of generating /producing/acquiring, processing and distributing/sharing knowledge is related mainly to scientific knowledge at the beginning of the 21st century. Scientific knowledge is typically more systematic than other forms of knowledge, and it expands its systematicity into STI policies. In a knowledge based society the systematicity of scientific knowledge concerns more than one single aspect of science. It enshrines several aspects of science: the environment in which it develops, how science expands knowledge and how the role of science is changing in the innovation process. In WP4, we are dealing therefore in details a num-ber of issues related to science.

extremely important in high technology industries that are dependent on continuous innovation for their very survival.

The aim of WP4 is not only to look at the role of STI from the perspective of the national policy process but also to offer certain conclusions for the tasks related to the progress toward a knowledge based society and economy in all the dimensions and also adding some aspects of a fourth, the European dimension in the small countries through the experiences of the KNOGG participants. Where are the KNOGG countries in the process which is aiming at the aggregation European R&D capacity and intellectual resources?

Beyond the introduction and the conclusions, there are four main parts of this paper. The first part is a discussion on *the influence of the domestic and international environment on STI policies in Europe at the beginning of the 21st century and the perspectives of the small countries. It is dealing with such important changes as the new trends* in science, technology, globalisation and the main aspects of the transition to a knowledge based economy. The second part is an analytical overview of the *main conclusions of WP1, WP2 and WP3 and of the issues related to the progress toward a European Research Area from the perspective of national policies*. The third part is looking at *the sources of success and failures in national STI policies* including the relevance of the main indicators, quantity and quality, the issues of the management of knowledge. The fifth part is dealing with the role of the societies: *public perceptions concerning R&D and innovations. The role of the public in the development of science, technology and innovations in the KNOGG countries and beyond.*

We are searching for answers to a few important questions, related to the past and the future trends: (a) What are those major changes in science, technology and in the social and economic environment which must be taken into account also in the small countries in shaping national policies? (b) Is the "logic" of the diverse policy experiences in harmony with the global and regional changes? (c) Are the instruments of national policies sufficiently conducive for increasing the capabilities of the small countries in the era of "knowledge based" development? (d) What have been the main sources of success and failure in STI and what did the countries "learn" from them? (e) What is the role of the "transnational actors" in small countries? (f) What is the specific role of the civil society in STI and to the transition to a knowledge based society? (g) While the role of the European Union will be dealt with in WP5 in details, we are looking at the potential importance of an evolving European Research Area for the small countries.

Many aspects of the above mentioned four dimensions of STI and a number of issues, including the theoretical, institutional market and corporate related aspects of scientific and technological development and policies, the production, distribution and use of new knowledge have been dealt with in the KNOGG project in WP1, WP2 and WP3 in general terms and from the perspectives of the small European countries. Some parts of this work package are based on the first three packages. The search for the optimal solutions and recommendations for governments requires however not only the evaluation of existing strategies and policies. It is necessary to compare innovation strategies, policies and policy instruments as sources of success stories and failures, to find the barriers to the application of the good practices and policy instruments, and evaluate certain methods like benchmarking and foresight. In relation to the enlargement of the EU it is worth to ask how the national STI policy models can be used to speed up convergence process between the old EU member countries and the accession candidate countries. It might also be of some value to look at the small country experiences from the perspectives of their contribution to ERA.

2. The influence of the domestic and international environment on STI policies in Europe at the beginning of the 21st century and the perspectives of the small countries

During the past decades, different experts, policy analysts, scientists, even historians and sociologists devoted a considerable amount of research to the process, contexts and impacts of R&D and technological innovations. Government agencies and international organisations also analysed the different aspects of the process. There have been major studies dealing with the entire innovation system and with the isolated factors within it. There have been studies containing explicit policy recommendations and those which evaluated different policies and institutional solutions and the various models of the innovation process. The interdependence of the elements of the innovations system has been also an important subject of the research. The studies revealed that the innovation processes vary across industries and over time due to differences in structural conditions, institutional factors, incentives and other variables. The "external" factors, meaning the socio-economic and political environment and the "internal" factors, which include the scientific and technological environment of the given era are also changing. The main challenges of the new era to which the different countries are supposed to meet are related on one hand to the changes in the system of science and technology and on the other, to the political, socio-economic and institutional factors.[7]

The specific characteristics and the competitive conditions of the different industries must be of course taken into account. Lynn K. Mytelka, an important international expert on innovations emphasised that at any given moment in time, industries can be characterised by a set of competitive conditions that relate to structure, technology and policy. She mentioned four of such conditions. One of these conditions is "the rupture". A rupture can be technological, (meaning that the new technologies break with the prevailing routines in terms of R&D procedures, accumulated knowledge and size requirements) policy rupture, (implying sudden changes in regulations or other areas in legislation) supply and demand size ruptures. The second condition is stability, marked by relatively slow and incremental change. (This can be stretched over many decades, influencing the speed of technological innovations, policies and markets). The third condition is intense competition, when some of the competitors are gaining important competitive power through innovations and diffusion, accelerating mergers and acquisitions, using predatory pricing, etc. The fourth condition is the

[7] When one is discussing the specific problems, it should not be forgotten that the Latin word, scientia itself means knowledge. According to the present usage of the word, the concept of "science" covers only certain types of knowledge obtained through systematic and unbiased observations, tested hypotheses. There are other widely used criteria. It should be applicable, it should serve as an instrument for predicting certain trends, it must be dynamic etc. As a process, it implies a never ending search for judgements to which the universal assent of experts may be obtained.

emergence of knowledge based networked oligopolies on global scale which can bypass or destroy the existing barrier to entry.[8]

2.1 The main technology blocs and their implications

The emergence of new technology blocs of revolutionary importance has been a fundamental source of both ruptures and of the growth of knowledge based oligopolistic technology networks. The fact that the second half of the 20th century has been characterised by an explosive growth of information and knowledge gained through scientific research has been generally recognised. As a result of the technological application of this knowledge, we have witnessed the evolution of new materials, informatics, communications, biotechnology and electronics. The 20th century has been the atomic age, the new biology age, the space age and the age of understanding the organisation of the universe. The major driving force behind high expenditure on science during the 20th century was mainly the arms race. Two World Wars and a very long Cold War had probably greater influence than the intellectual competition in a free environment for scientific discoveries and publication in universities and scientific institutions under the motto "publish or perish", led by a sense of curiosity and competition for promotion. The five technology blocks that have been playing a key role in shaping the new technological era since the 1960s, namely, microelectronics which are the foundation of the information technology, new materials technology, new biotechnology, propulsion and space technology, and power technologies are generic, multipurpose technologies. Their development and global diffusion are at different stages and in different clusters. At the early 2000s it is already possible to evaluate their impacts. Different calculations indicate, that the "embodied" use of those technologies has been a crucial factor in the speed and spread of economic and especially productivity growth in the major industrial countries. The concept of "technology" included of course a number of different factors, beyond the "tangible assets" or physical capital, like the increase of knowledge through the growth and influence of science (universities, research centres) and other institutions of the social system of innovations, the improvement of human skills, the advancement in the capabilities of industry and of the service sector to absorb and use, to adapt, to commercialise and market new technologies etc. It is evident that for the assessment of those technologies which could have a strong impact on technological competitiveness, wealth creation and the quality of life, the experiences of scientists from different disciplines, business people, government officials and even the interested lay people should be brought together.[9] Future potentials and the impact of the different new technology blocs.

What are the main trends of scientific and technological development and how they will influence of the small countries? The paper of the Dutch team in the context of

[8] Lynn K. Mytelka: Competition, Innovation and Competitiveness: Learning to innovate under the conditions of dynamic industrial change. A conference paper. Centro Cultural de belem, Lisbon. Oct. 1998.

[9] Foresight is presented by some of its advocates as a brand new exercise. In fact the different "actors" of the STI process have been interested also in the past to study the future potentials and the impact of the different new technology blocs.

WP4 offered a general answer. "*The changes can be characterised as a growing complexity of new core technologies while small countries like the Netherlands have limited resources to develop an extensive national treasure R&D infrastructure. An important characteristic of high technology industries in which these complex technologies are used is their ability to source out parts of the technology process. In order to compete for the high technology parts of these complex technologies it is important to develop effective STI policies.*" The problems are even more difficult for a small countries with more limited resources. There is a temptation by the scientific community for copying the universal character of the research base of the large countries. There is also a domestic pressure that they should at least understand the national implications of the new technology blocs. At the same time they cannot afford universality. The increased internationalisation of R&D offers opportunities for small countries like the Netherlands to upgrade their knowledge base if they implement the right policies. This means also greater openness for international co-operation and the greater flexibility of the STI system, in order to adjust faster and more efficiently.

The answer to the above questions, concerning the changes and their implications for the small countries may be even more difficult if we try to anticipate the future path of scientific and technological changes and their influence on innovations, more specifically. The most important innovations of the next two or the decades will most probably take place in four basic areas: information technology, bio-technology, micro-electromechanics and the closely related nanotechnology. These technologies and their combinations will have a major impact on all areas of human activities. The growth of computing power, the smarter software, the near universal access to information and to many sources of knowledge will be linking most part of the world. Information technology will make most of the socio-economic processes interactive. In the developed part of the world a special "personal infosphere" will develop around the individuals, which will be tailored to their individual needs. This will be also an important source of empowerment in many areas of their life.

The promises of biotechnology are even more important for human beings. Some aspects of biotechnology, like its use for warfare, cloning, genetical engineering of human beings or GM food production will remain controversial, but their development will continue anyway. The role of biotechnology in the improvement of human health and in pharmaceuticals will open qualitatively new areas for treatment of different diseases, enhancing for example human immune response.

There will be a dramatic increase in the capabilities of micro-electromechanic devices. A revolutionary development in the field of nanotechnology, particularly those technologies which operate on the frontiers of information technologies and biotechnology will open new areas in medicine, scientific research, in transport, industry and agriculture.

An other important promise of STI may be realised in the global energy economy. It is necessary to emphasise however, that not only the technologies and related innovations matter for the purpose of influencing government policies, but their social, economic, environmental and political impact. This depends on a number of factors like

* the character and speed of their global spread,
* the differences of the countries to adapt to the changes.

One of the very important characteristics of the evolving new technologies has been an unprecedentedly large qualitative difference between the new technologies and those representing the earlier technological eras in the products and processes which they are resulting in and also in their influence on productivity changes. They expanded the productive frontiers of individuals, firms and of the countries at a historically unprecedented rate already at a rather early stage of the changes. *Their global spread has been much faster than of the key technologies of the earlier stages. This is due to several new socio-economic factors, like the faster development of the educational system and the internationalisation of science and education, the information revolution and its implications on the patterns of consumption and production etc. A key role is played by the transnational corporation which are the most important global agents of the diffusion of new technologies.* The role of science and technology in international competition and the related national policies have been also accelerating the diffusion process. The transition to the new technological era on global scale is however still a long term, complex and uneven process. One of the factors of the uneven character of the changes has been the economic interests and possibilities of the sources of the new advanced technologies in sustaining oligopolistic position and using their market power in influencing the forms, the speed and the costs of the diffusion process. The other source of unevenness has been the relatively high "threshold" for the latecomers. It is costly and takes a relatively long time to build the necessary technological infrastructure, the national capacities and develop technical capabilities and skills for the support of modern industries and services depending on the advanced technologies. Even the developed industrial countries are facing difficult tasks in their adjustment to the relatively rapidly changing requirements especially in the field of the scientific infrastructure and in the educational system. The newly industrialised countries comprise a characteristic example for the problems involved. They could achieve rapid progress by importing advanced technologies for upgrading certain sectors in their economy. They were able to develop export industries by using their cheap and relatively skilled labour force. In the coming years they will have to make further great efforts in upgrading their technological capabilities or they will not be able to "graduate" into the group of developed industrial economies in the world market. (In the literature on development theories, the dilemma they are facing with is often called the "third stage of modernisation", which would require the upgrading of human capital, rapid progress in national R&D infrastructure and other supportive efforts in the socio-economic life.) The former socialist countries, which in spite of the relatively large number of university graduates in the labour force, and the relatively well developed scientific infrastructure remained in a peripheral position from the point of view of innovative capabilities and international technological and economic competitiveness, are facing also major problems and dilemmas in creating the structural conditions for world market integration. They will have to fill several missing elements in bridging the gap, including entrepreneurship, access to financing, efficient participation in those institutions (transnational firms, intergovernmental structures, scientific co-operation networks etc.) which are playing a crucial role global science and technology. There are however important assets available which could serve as instruments in accelerating the catching up process in certain segments of their economy. (The catching up process in general terms has been dealt with both by the old and new regimes in a simplified way forgetting its cultural-educational, structural and especially infrastructural conditions of it.) It would be a major waste not only for them but for the global scientific community if amidst the difficulties of the transition process, the human capabilities and the R&D infrastructure, would be lost or reduced to a meaningless minimum. It is not just the fact, that the relatively poor society played a high price for building up the "human capital". It is evident, that those capacities in the case of correct national policies could help their faster and more efficient integration into the global scientific and technological system. There are of course important quantitative and qualitative differences between the former socialist countries concerning those human and other scientific-technological assets. While it is true, that in some countries they are probably more compatible with and more closely tied intellectually to the industrial world than any other institutions in those former socialist countries (that is why they are exposed to the dangers of the brain drain as well) in other countries especially in those where they have been isolated from the main scientific and technological centres for long decades, they are weak and cannot help too much the modernisation process. It is an unfortunate similarity however in all those countries, that due to the diminishing government subsidies, declining orders and other reasons, the R&D sector in those countries is facing great difficulties. Many good researchers for example in Hungary, Poland and Russia left the areas of scientific research. They either went to business (which in many cases has been useful, resulting in small and efficient high-tech private firms) others, went to work in foreign firms but a great number of them left their countries even for positions which were inferior in relation to their qualifications. The R&D sector in those countries could still be saved by wise government policies and support, internal restructuring and through efficient participation in the global system of science and technology. Saving science as a major national asset is particularly important in an era, when its role in the innovation process has been on the increase.

2.2 Science and innovations

It is far from the truth to assume that all the achievements of the new technology are the consequences of a linear process which started with scientific research and led to the mechanical application of scientific results. Even in the high technology sectors, *many of the new products and processes are not necessarily and directly science based*. The role of human creative activity and experiences in innovations, accumulated and formed after thousands of "tests" in the market by consumers and practical experiments with existing products has always been very important. Engineers have their own creative traditions, quite distinct from the scientist's. *In an era however when the scientific character of new technology has been increasing the* *invention and innovation process, the application and diffusion requires not just the involvement of science in each phase of the process but a critical mass of researchers and engineers.*

There are also great differences in the level, structure, capabilities and concrete role of science between the different countries. The scientific and technological map of the world and also of Europe is highly diverse. There are also important policy implications of this diversity, particularly in the field of innovation policy. Innovation policy as a concept emerged in the course of the 1970s as the amalgamation of science and technology policy and includes a broad area of different factors. It reflects on one hand the fact, that the input of science became more important, and on the other hand, the successful application is a key factor in the economic return of the ever increasing R&D expenditures.

It is not only the high technology sector however, which makes the active participation of science indispensable in the economic activities. While, for example the main technological blocs and high tech industries have major influence also on the traditional sectors it would be an error to overlook the fact that for a small country in the middle level of development may be gaining more by promoting high-tech innovations and high-tech improvements in those (traditional) industries in which it has already accumulated distinct capabilities of its own development. The more, however, such a country succeeds in catching up and the closer it comes to the level of its most advanced competitors, the more it has to search for country specific high-tech market niches.

Regardless of the extent to which a certain brand of technology is science based, there has been an important interaction between the two sources of progress. The use of new technology in science for example, provided a whole host of opportunities for constructing new experiments or building more precise measuring instruments. New fields of science emerged and developed as the result of the possibility of electronic computing. The concept of the knowledge based economy or knowledge based society express the dynamics of interactions between science and technology. It is evident that R&D are at the heart of a complex interactive system. It is very difficult to measure the expansion of human knowledge. It has been generally recognised that particularly since the 1960s there has been a historically unprecedented expansion of new knowledge about nature, materials, and technology and about the societies.

Science also went through different stages, which included its institutionalisation, professionalization and industrialisation. During the past century, science has become an extremely diverse and relatively large profession. The annual global R&D expenditure is estimated around 600 billion dollars for the later years of the 1990s, based on global GDP data and calculated on commercial rates. There is a more or less general consensus among academics that it has grown between 30 to 50 times as compared to the 1950s. The increase of the amount of knowledge has been highly unequal in different areas. Its growth depended on one hand on the "effective demand" which stimulated research, meaning first of all the demand of the sponsors and to a certain extent on the urgency of the problems the solution of which required new discoveries and approaches. It has depended of course also on the capabilities of the researchers. During the Cold War years national defense expenditures and the competition between the two main confronting blocs has been a crucial factor in the "effective demand". The commercialisation of STI and the role of the corporate sector as a source of demand are also related to international competition. The educational system particularly higher education as an important source of effective demand has always been more stable and less controversial. While the *impact of the changes has been pervasive across a wide variety of production processes and in a large area of product "families"* demand and supply factors have been playing an important role in the unequal spatial spread of new knowledge. *The global diffusion and the various application of increasingly complex technologies has been resulting in major changes first of all in the industrial world in output and consumption patterns, skills, lifestyles and institutions which had also unprecedented consequences for the other regions. It has changed already the technical structure of the economy in the industrial world and induced changes on global scale*.

The increasing importance of the innovation proves for the countries and firms made also the uncertainty and risk factors involved more important. Historical studies proved that the majority of innovation projects fail. Large sum of money is lost by business through failed innovation projects. The potentially high rewards make the high level of uncertainty acceptable in large firms and larger countries easier. In the smaller countries the impact of failure is a relatively greater loss. In fact, there are different sources and factors of uncertainty, like the technical uncertainty, the economic uncertainty (changing economic conditions) and the general business and market uncertainty (the size of demand, competition, etc.). One of the reasons, why the role of governments became more important has been the greater reluctance of business than governments to proceed with STI. Because of uncertainty tends to increase with the magnitude of technological change anticipated and the length of the time necessary, a growing part of business STI shows growing preference on short term, low risk and relatively small advances.

2.3 The shifts between the role of "hierarchies" and the markets

The importance of the market pulled and technology pushed innovations has been an important subject of research on R&D. It has often oversimplified the process also in the past. At the beginning of the 21st century the problems are much more complex. Traditionally many of the theories emphasised that markets fail to produce enough knowledge because innovators cannot capture all the gains associated with creating new knowledge. Instead scientific and technological development is likely to be a process of creative destruction, with a succession of monopolistically competitive technologies and firms, as originally described by Joseph Schumpeter. Markets alone may not converge on a single most efficient solution, and technological and regional development will tend to exhibit path dependence.

There is an other significant, in a way contrasting couple: the relative role of governments (Hierarchies) and the market as sources of demand and incentives. The relationship between the two sources is also more complex than the dominating views in different theories.

According to these views governments are concerned with the social impacts of STI and with the social return, while firms are interested in the business aspects of the process and in the actual profit. During the second half of the 20th century a large proportion of the effective demand for research and development has been realised through public funding in the main innovating countries, which have been indirectly and sometimes directly helping the increase in the efficiency of specific firms. During the Cold War years a large part of the priorities determined by the governments have been related to defense. The contraction of the global defense sector resulted in important reduction in research mainly in the former Soviet Union. There has been neither a major setback for global research nor a radical increase in research for the solution of many burning issues of humankind responding to the evolving social demand in the field of new energy sources, safer technologies, health related issues, etc.

There has been an increase in the role of the market forces in the demand for research and development, the drive for greater efficiency and economic rationality is reshaping the role of science and making national science policies more pragmatic and market oriented. Several components of those policies, such as the selection of research priorities and the integration of science policies with other social objectives (for instance, environmental protection and economic development), are being redefined to secure higher yields. The R&D policies of large corporations, which formulate objectives to correspond to future changes in demand, are also being influenced by these changes. Many firms shifted a greater proportion of resources away from long term investments toward shorter term projects. R&D for immediate problem solving or near term development is prioritised over long term goals. A growing part of basic research in certain industries is directed toward product development. There has been almost always a major difference in the relative role of the market factors and the state between the United States and Europe. Most of the smaller European countries devoted even greater attention to basic than to applied science.

The growing commodification of science is also related on one hand to the high costs of research and on the other hand to the sources of its financing. The increasing role of private sources presuppose the private ownership over its results. Many private research universities realise large revenues from their patents. Some of the experts suggested that moving science closer to the market may promote more efficient and more effective mechanisms for advancing commercial technologies and knowledge for practical use. Others have characterised this situation however as the "end of the era of great science."[10] This may be an overly pessimistic view. Expenditures on science will have to increase also in the future, not only in those areas, which serve directly applications and competitiveness. There are however some important questions.

[10] The debate about the implication of commercialisation influenced the World Conference on science in the 21st Century, which was organised by UNESCO in Budapest, in 1999. A number of participants of the debate expressed great concern for the potential negative role of commodification.

Coupling research to commercial interests does not necessarily provide incentives for generating new knowledge in those areas where the "social usefulness" is the main motive. This also implies however the shrinking of that part of knowledge which can be considered as "public good". The public character of scientific knowledge may be under a growing threat. This may adversely influence basic research which cannot be directly commercialised. It may also adversely influence the diffusion of new knowledge. Some of the international agreements in WTO and national legal systems may be resulting in the greater protection of knowledge through patents or greater secrecy in order to provide incentives for investing in knowledge production. Other forms of protection are also envisaged in the TRIPS agreement of WTO. All these imply major new tasks and challenges to government policies. Many issues of research, development and innovation became also important tasks for the different international intergovernmental organisations. In any case, the greater privatisation of R&D is increasing the role of the patent system. Patenting has become an important part of private business through licensing and cross licensing. With more complex products that are in the market, a multiple of patents are needed.[11] The patenting process made knowledge more easily tradable.

In an era, when the markets are playing a crucial role in STI, the creation of new markets and acceptance of new products by customers have special importance, particularly in Europe. A document of the EU stated: The market's impact on innovation will grow in the future, and the majority of managers expect that markets will become more receptive for introducing new products. In this context a deeper understanding is urgently required of the relevance to innovation of market dynamics, including the emerging concept of "lead markets."[12] All these influence the functioning of the economic system, which is characterised increasingly as the "knowledge based economy".

2.4 The realities of the knowledge based economy

An OECD document has defined knowledge-based economies as systems directly based on the production, distribution and application of knowledge and information.[13] In the literature, there are three main approaches to the new role of knowledge. First, there are those who consider knowledge as quantitatively and qualitatively more important factor in economic growth than ever before.[14] There is an other view, according to which knowledge as a commodity has become more important than in the past, and the essence of the knowledge based economy is the knowledge market, which is based on the information revolution.[15] There is also an argument that codified

[11] A car for example may contain 2000–3000 patents. These are held by a couple of hundred different owners.

[12] Innovation policy: updating the Union's approach in the context of the Lisbon strategy: COM (2003) 112 final. Commission of the European Communities, Brussels, 11.3.2003.

[13] OECD, The Knowledge Based Economy. OECD/GD(96) 102, p. 7.

[14] Drucker, P: From capitalism to knowledge society. In Neef. D. (ed.): The Knowledge Economy. Woburn MA Butterworth, 1998 p. 15 .

[15] Lundvall B. A. and Foray D.: The knowledge based economy: from the economics of knowledge to the learning economy. In OECD Employment and Growth in the Knowledge Based Economy, Paris, 1996. p.14.

knowledge became more important than the tacit, person-incorporated knowledge in conduction economic activities.[16] One must add however certain qualifications to this views. First, the role of knowledge has always been important. Since the earliest analysis of modern economic growth, knowledge and technology have been recognised as factors of key importance.[17] The importance of knowledge and information in the contemporary economy has long been established. The notion that information and knowledge are of central importance both in the process of production, as well as an essential part or the final commodity produced, is almost a platitude and it always has had some weight. Knowledge was needed to make a spear, as well as to make a microchip. What has changed, apparently, are the quantity, the quality, and the density of knowledge and information, the speed in which it circulates and changes, the proportion of it which is embodied in the final product. The coherence of the definition has been questioned also by several authors.[18]

We have to be aware that knowledge is not a normal "input factor". To be able to understand knowledge, we have to avoid treating knowledge not so much as a thing and instead move towards considering it a process itself. We should also avoid the mystification of knowledge. Looking at knowledge as a process, we can see that knowledge is circulating by definition. It is logical, considering that knowledge, which goes unutilised, which is locked-up, thrown away, or forgotten, is, for all intents and purposes, not knowledge. The circulation of the positive loop effect of knowledge creation, got accelerated through the advent of modern Information and Communication Technologies. We can also expect that through modern ICT, knowledge can get multiplied faster (in a sense of vertical dispersion; spread of knowledge) and therefore revolutionise easier (in a sense of picking it up, developing and elaborating it: innovation).

Knowledge, is an unlimited resource /at least in principle/for humankind. Knowledge based economy became particularly important concept in an era when the apparent scarcity and limitations of other resources entered into the realm of socio-economic analysis and the information revolution opened up unprecedented perspectives for spreading intelligence and skills. Knowledge as a resource can be considered infinite in all directions. The WPs of the KNOGG project also affirmed that the innovation policies of the governments should be treated as the complex totality of science and technological development policies and the related policy areas, including education, health, economic policies. According to the concept we suggest for using in KNOGG a knowledge-based economy embodies not just a fuller recognition of knowledge and technology in economic growth, but a system in which the societies are able and ready to meet the new challenges of the present and ongoing scientific and technological

[16] Abramowitz, M. David, P: Technological change and the rise of intangible investments: the US economies growth path in the twentieth century. In OECD Employment and Growth in the Knowledge Based Economy, Paris, 1996, p. 35.

[17] The concept of knowledge and technology have been interrelated in many ways. Technology for example can be defined as a cumulative quantity of knowledge about different technics. Technology is often defined as a tangible embodiment of knowledge in an operating system.

[18] See for example Smith, Keith: What is the "knowledge based economy"? UNU6INTECH discussion paper 2002. ISSN 1564-8370, 2002.

changes of 21st century. A knowledge based society is first of all an innovative society which possesses a community of scholars, researchers, engineers, technicians, research institutes and firms engaged in high-technology production and service provision, forming a national innovation-production system which is integrated into international networks of knowledge production and diffusion knowledge based society is also an information society. The information dimension of the societies is developing into a new “info sphere” for persons, firms, governments and international organisations. The knowledge system includes also management. The management of state and society in a knowledge based economy must be using the advanced methods. In the application of the principles of scientific management information, knowledge, and science – including social science – are self-evidently the central requirements. They provide the means necessary to coordinate and control the increasingly complex operations of the economy and the political life. Some expert argued that it was the exponents of Scientific Management, in its broadest sense, who unleashed the Information Revolution.[19]

The progress toward the knowledge based economy is highly unequal in the different parts of the world. First of all, the high concentration of R&D which characterised the 20th century, remained more or less unchanged. There is a remarkable continuity in the overwhelming role of about 20 countries from among which, the United States, UK, Japan, France, Germany, the Russian Republic and increasingly China devote more resources toward R&D in absolute terms but also larger fraction of their resources. There are also a handful of small, though technically advanced countries which are in the “group of 20”. The total investment of the EU in R&D is around 1.8 per cent of the GNP and the progress toward the 3 per cent goal is slow. The US is investing around 2.7 per cent of its GDP into research and development. In 2000 it was about 300 billion dollars, about 100 billion more than the EU total. The R&D expenditure of the developing countries together was about 40 billion dollars.[20]

It is an important question also from the perspectives of the KNOGG participants, why some countries invest more in R&D than others. The literature offered different explanations. One of the explanations is based on the character of specialisation of the different countries. According to this view, countries, which are specialised to high technology industries, to goods and services which are research intensive,[21] will have to invest more in R&D. This explanation is disregarding the fact that in order to develop research intensive production and services, the countries need already a well developed research infrastructure and high investments in R&D and education. An other explanation is based on the size of the firms. Countries, which are the home of large international or transnational firms may have the resources, the scale available and the threshold of R&D infrastructure.[22] This explanation is partially relevant. It has

[19] Kumar (1995).

[20] Calculated on the basis of UNCTAD and UNESCO statistical data.

[21] See J. Eaton and S. Kortum: International Technology Diffusion. International Economic Review 40. No. 3, May 1999. pp. 1-33.

[22] F. M. Sherer & David Ross: Industrial Market Structure and Economic Performance 3rd ed. Houghton Mifflin Company, Boston, 1990. pp. 653-660.

particular importance in the smaller countries, like the Netherlands, Finland, Sweden and Switzerland. A third explanation is based on the cultural tradition and the policies of the countries. There may be other factors, like the relative role of the market and of the "hierarchies", the development level of the given countries, etc.

Knowledge, in a "knowledge based" economy or society did not and would not replace the other two factors of production: labour and capital and the economic and entrepreneurial infrastructure. It has become however a very important condition for the increasing efficiency of the other factors. It has become a major source of competitive advantages.[23] Knowledge is only a necessary but not sufficient condition for market success either. Only when it leads to marketable technological innovation does knowledge have value for the firm. Firms must be able to finance new technology ventures, to hire and train skilled scientists, engineers, managers and production workers, they have to be able to protect their innovations from imitators, they have to acquire complementary skills to make their technologies useful and they have to gain market acceptance. Firms increasingly depend on specialised knowledge in a number of areas to provide a continuously replenish able source of competitive advantages. They have to be involved in a complex array of collaborative arrangements. Tacit knowledge is the most valuable part of knowledge. The linear model of innovation which implies that innovation proceeds sequentially from new scientific discoveries to new processes, product and services is limited in its descriptive and predictive power. Innovations can take many forms, including incremental improvements to existing products or processes, applications of existing technology to new markets and the uses of new technology to serve an existing market. Science plays a crucial role in innovations but not necessarily the main driver of new processes, products and services in all areas. New ideas for innovations can come from many sources. Nevertheless science became indispensable throughout the innovation and product development process in a number of areas, particularly in information technology, biotechnology.

2.5 The knowledge corporations and the knowledge workers

Firms have been traditionally divided into three main groups: The innovators, the first followers and the copiers. In a more general understanding an innovative corporation, or firm in the new era of technological changes is dependent on intellectual capital to a much greater extent than its predecessors were. The advantage of inventing and bringing breakthrough products or services to market first became shorter-lived than ever, because technology will let competitors match or exceed them almost instantly. To keep ahead of the steep new-product curve, it will be even more important for businesses to attract and retain the best thinkers. Companies will need to build a deep reservoir of talent – including both employees and free agents – to succeed in this new

[23] For the OECD as whole, physical investments at the end of the 1990s have been two and a half times greater that knowledge investments as the percentage of the GDP. In terms of growth rates, knowledge investments have been growing faster than physical investments in the US, in the Nordic countries and in France. See Investments in tangibles and knowledge in "The Knowledge-Based Economy". A set of Facts and Figures, OECD, Paris, 1999. p. 9.

era. Attracting and retaining an elite workforce will require more than high remuneration. Corporations need to create the kind of cultures and reward systems that keep the best minds engaged. The old command-and-control hierarchies, with their civil-service-like seniority, are fast crumbling in favour of organisations that empower vast numbers of talented and young people and reward the best of them according to their performance.

There are many areas where the technological changes, particularly the information and communication technologies transformed already the management of the firms. The "wiring" of the firms, the "digitalisation" or the E-business are the most often mentioned instruments. Large and small firms can use ITC technology to gain economies of scale. Larger companies harness ITC technology to reduce the costs of the management of large complex systems. Digitisation which stared in large scale already in the last stage of the 20th century has replaced office workers with computers and networks in doing different routine tasks in accounting, calculations product design and in many other areas and operations, resulting in huge savings and vast improvements in speed. These in the US alone accounted for over half of all labour costs. From among the many components of the ITC technologies which are driving change, the most multi-dimensional is the spread of the use of Internet technologies. The Net has already be-come an instrument with revolutionary consequences, most of which we have only begun to feel. The Net gives everyone, even in the largest organisation, from the lowliest clerk to the chairman of the board, the ability to access a mind-boggling array of information – instantaneously and practically from anywhere. This is however only one of the stimulation factor for management via the Web. It is also an instrument for promoting constant change and activities organised around networks. Net allows employees, outside contractors, teams of designers, prototype producers, manufacturers, and distributors anywhere in the world to converse. The language barrier in this context will soon be an issue of the past. The rapid flow of information will permeate the organisation. Orders are increasingly fulfilled electronically without a single phone call or piece of paper. The "virtual financial close" may put real-time sales and profit figures at every manager's fingertips via the click of a wireless phone or a spoken command to a computer.

The organisational chart of large-scale enterprise which has been defined as a pyramid of ever-shrinking layers leading to a CEO at its apex will also change. The chart of a knowledge based corporation will be more likely look like a web: a flat, inter-connected form that links partners, employees, external contractors, suppliers, and customers in various collaborations.[24] The larger and smaller firms will grow more and

[24] In this context the process is not unambiguous, particularly if we include the dimension of competition. I quote here the views of an American expert: "There is much talk these days about a new management style that involves flat hierarchies, mission orientation, flexibility in strategy, market positioning, reinvention, restructuring, reengineering, repositioning, reorganisation, and re-everything else. Are these new insights, or are they fads? Are they appropriate for all organisations? Why are we seeing this new man-agement style?

Let us look at the two cultures of competition. In bulk processing, a set of standard prices typically emerges. Production tends to be repetitive – much the same from day to day or even from year to year. Competing therefore means keeping product flowing, trying to improve quality, getting costs down. There is an art to this sort of management, one widely discussed in the literature. It favours an environment free of surprises or glitches – an environment characterised by control and planning. Such an environment requires not just people to carry more interdependent. Fewer companies will try to master all the disciplines necessary to produce and market their goods but will instead outsource skills – from research and development to manufacturing – to outsiders who can perform those functions with greater efficiency.

The knowledge based firms will not have one ideal form. Some will be completely virtual, wholly dependent on a network of suppliers, manufacturers, and distributors for their survival. Others, less so. Some of the most successful companies will be very small and very specialised; others will be very large in size, scope, and complexity. Some enterprises will last no longer than the time it takes for a new product or technology to reach the market. Once it does, these temporary organisations will pass their innovations on to host companies that can leverage them more quickly and at less expense.

All these changes imply not only new challenges to the firms of the small countries, but also new opportunities, because ITC and the Net reduces the size specific problems.

The knowledge-based economy requires new types of skills and knowledge from managers and workers alike. Many of these skill may not be readily available in the small countries. The altered business structures' management is less engineering-oriented than before. On the other hand, "knowledge workers" use specific new skills that are characterised by more analytical capability and decision making. Technical knowledge became increasingly codified, thus, workshop employment does not require else than basic technological knowledge. On the other hand, running automated production equipment requires thorough knowledge in informatics, capabilities of communica-tion with computers and tacit knowledge of how and when to (manually) intervene in the work of automated systems. All these new knowledge requirements pose new challenges for the education systems of KNOGG economies. Finnish data proves a very high and increasing level of participation in higher

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out production but people to plan and control it. So it favours a hierarchy of bosses and workers. Because bulk processing is repetitive, it allows constant improvement, constant optimisation. And so, Marshall's world tends to be one that favours hierarchy, planning, controls. Above all, it is a world of optimisation.

Competition is different in knowledge-based industries, because the economics are different. If knowledge-based companies are competing in winner-take-most markets, then managing becomes redefined as a series of quests for the next technological winner – the next cash cow. The goal becomes the search for the Next Big Thing. In this milieu, management becomes not production oriented but mission oriented. Hierarchies flatten not because democracy is suddenly bestowed on the work force or because computers can cut out much of middle management. They flatten because, to be effective, the deliverers of the next-thing-for-the-company need to be organised like commando units in small teams that report directly to the CEO or to the board. Such people need free rein. The company's future survival depends upon them. So they – and the commando teams that report to them in turn – will be treated not as employees but as equals in the business of the company's success. Hierarchy dissipates and dissolves.

Does this mean hierarchy should disappear in meatpacking, steel production, or the navy? Contrary to recent management evangelizing, a style that is called for in Silicon Valley will not necessarily work in the processing world. An aircraft's safe arrival depends on the captain, not the flight attendants. The cabin crew can usefully be "empowered" and treated as human beings. This is wise and proper. But forever there will be a distinction – a hierarchy – between cockpit and cabin crews." W. Brian Arthur: Increasing Returns and the Two World of Business. Harvard Business Review, July, August 1996. P. 3.

education that may mean increased knowledge. However, Hungarian experience showed that despite of increasing participation in higher education, without the improvement of the quality of the education particularly in the recently created universities without accumulated knowledge and experiences the increase in quantity does not automatically mean an increase in the level of knowledge and skills.

New skills are needed also for the emerging information-age workplace. Knowledge Economy and Society requires a more "knowledgeable worker" in the system. Even the content of functional literacy is changing. It includes the capabilities to work with the instruments of information technology. We are also talking about "life-long learning" and "on-the-job-training" nowadays. In the past it might have been enough to train a worker on one production method. The method did not really change for many years. Given that the "loop" is spinning a lot faster now, means the speed of knowledge creation got accelerated, workers need to get retrained with an increased sequence. This sequencing is becoming so fluent that constant retraining has become an integrated part of the job. "Life-long learning" which gets implemented through constant "on-the-job-training", requires a different attitude of the worker towards his profession. This is what should be understood by the term knowledge worker. Therefore, knowledge worker applies not only to brainworkers, information jockeys or information mechanics, employed by knowledge-based software companies. If workers are to become intelligent users of technology and information, they should also learn how to be creative and innovative. They should be involved in problem-solving and research and should be able to tackle case studies and understand how to analyse data and draw intelligent conclusions. Education faces the daunting challenge of preparing individuals for the information-age society by teaching them: how to manage an avalanche of information, how to prepare the most efficient human capital for the brain-intensive marketplace; how to prepare flexible human resources to meet the uncertainties of a global economy; how to innovate to keep up with a high-speed, knowledge driven, competitive economy in the workplace.

Another problem tied to education is the loss of educated persons as the results of emigration. Fear of brain drain is still intensive. The greater is the emigration of skilled people, the less a small country can provide state-of-the-art research and education facilities for students and researchers. It seems that a certain threshold level of local research and education has to be surpassed in order to net out emigration and immigration of skilled personnel. The Finnish example proves that migration became common prac-tice for young professionals to learn abroad.[25] On the other hand, in

[25] The Finnish National Report stated that: "Though at times raised as a threat, brain drain from Finland has so far not threatened the economy. As there is no shortage of university graduates, the graduates may find it tempting to migrate in order to find employment that better fits their skills and knowledge. Particularly, during the deep economic recession of the early 1990's, many highly educated people became unemployed, and among those who left abroad, few have returned. In contrast, the rapid growth years of the late 1990s' witnessed a new phenomenon, "brain circulation" of short stays abroad to gain new competencies. About 85% of those who move abroad return within 5 years and consequently may complement the national knowledge pool with what they learned and skills they acquired abroad. Shorter stays abroad have, in fact, been an integral part of national ST&I policy since 1996, when The Science and Technology Policy Council of Finland recommended the promotion of expert mobility and intensification of its monitoring. The only specific ST&I policy scheme that can be considered as directly enhancing human mobility between firms and universities is the post graduate training

countries with less developed higher education systems brain drain may start even on university level siphoning the most talented students to graduate at internationally renown universities. The lesson of knowledgeable person's migration patterns is that local facilities' development is unavoidable if massive brain drain is to be replaced by an exchange of knowledge between local and foreign knowledge bases. This later also requires a general opening up of economies and societies.

Opening up the economy towards the world economy is an option that can be hardly omitted by small countries in the current situation. Once this basic policy decision was taken STI policies may become an important driving force of the restructuring process of small economies. Depending on the basic philosophy of the governments, STI policies may act as provider of favourable innovative climate and proper institutions, or may take more concentrated development actions as part of an active industrial policy. This fundamental orientation of economic policy, and the chosen tasks and tools together may characterise typical STI policy mixes. The typology applied here rests on the understanding of STI policies deployed in different countries in the past 1–2 decades.

2.6 Globalisation of science, technology and innovations

Globalisation has been an important issue, the consequences of which have been analysed in the KNOGG participant countries. Knowledge flows always existed between different human communities in a great variety of forms and through different channels. Science has also transcended national frontiers. During the second half of the 20^{th} century the internationalisation process of science and technology has become more intensive. The greater mobility of people, international education, information and communication technologies, the internationalisation of firms and particularly the role of transnational corporations resulted opened a new chapter in the history of internationalisation of STI. While the process is certainly global, some regions of the world particularly North America, Japan and Europe have been much more affected by the globalisation of science and technology, than other parts of the world. Four main dimension could be observed in the internationalisation of STI: The international diffusion of nationally developed inventions and innovations through different channels of technology transfer, the global sourcing of the transnational corporations, global strategic alliances of firms for the developing new technologies and the role of international, intergovernmental organisations in diffusing new knowledge.

The information revolution created also new instruments and incentives for international co-operation in R&D. Information technologies facilitated for symbols and sounds to overcome the traditional barriers of time and space. At the same time as the results of the scientific-technological and economic changes there has been a world

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programme (POSTE), administrated by Academy of Finland. In the framework of the programme, a doctoral student receives a grant to enable full-time work to complete the dissertation. According to the respondents of the private sector, however, the mobility of researchers is presently "non effective", and this measure concerns intra-country mobility." In other words, studying abroad is not necessary, but it is something that is encouraged and promoted at many universities. Working abroad depends much more on each individuals opportunities.

wide expansion of demand of information. The process of internationalisation will be strengthened also in the 21st century by the creation and operation of vast information systems connected by a telecommunications network the means through which an enormous volume of knowledge may flow between countries. Participation in such networks has become of key importance in the life of states. It became a most important factor of their differentiation, determining whether they fall behind, catch up with others, or lead the way. Some other changes, which intensified the internationalisation process, are connected with the international education. While the degree of the internationalisation of higher education is still much lower than it was the case of the medieval universities when sometimes the majority of the students and the professors were foreigners, it has been growing rather fast and the numbers are quire impressive. From the perspective of the small countries the internationalisation of STI, the diffusion of the new technologies and their effect on the changes in the patterns of the international division of labour are particularly important. The new technologies are chang-ing the organisation of operations, the location strategies and the importance of the economy of scale, the relative importance of the abundance of labour and materials, of distance factor in production and location. They are opening new patterns both in competition and co-operation. In principle these changes may imply a more favourable environment for the smaller and weaker countries as the exploitation of their particular advantages in science and technology depends to a great extent on their integration to the large international systems. Globalisation of STI implies important opportunities for the small countries also as a potential source of new knowledge. In a globalised knowledge system however it is very easy to become marginalised in the main flows of knowledge. All these imply new challenges and tasks for public policy. Instruments, which promote the inflow of new knowledge, like measures which upgrade the national R&D infrastructure, expand the national reservoir of highly skilled people, attract high technology research and production activities of the transnational corporations are particularly important for small countries in order to be able to use those opportunities which are offered by the globalising process of STI. The framework programs of the European Union and the designed European Research Areas should be also looked for the perspective of their contribution to STI capacity building and utilisation on European scale in a globalised framework. The understanding of the relationships between different areas of the EU policies is very important. From among the different policy areas it is for example essential to understand the interrelations between innovation, R&D and competition policies.

3. The main conclusions of WP1, WP2 and WP3 and the progress toward ERA

3.1 Size and innovations: the specifics of the small countries

One of the most important common characteristics of the KNOGG countries is their relatively small size. It has become evident also in this project, that there are many definitions for smallness. The majority of the definitions consider small state as a unit with relatively modest territory and population. They are however not of uniform economies, markets, they may have great differences in their scientific and technological capabilities. Some of the small states accumulated skill, knowledge and entrepreneurial experiences. Due to their structural characteristics, some of them may have a much greater absorptive capacity of new information and knowledge than other small countries or even some of the larger states.

These differences are reflected by the different indicators, which are used for comparing STI capabilities, which have been discussed mainly in WP2 and WP3.

For characterising the size of the countries participating in KNOGG we used first of all the territory and the population.[26] We also looked at the size from different perspectives: how it influences the magnitude, the structure and the effectiveness of the national innovation system? We have analysed a large number theoretical and practical issues and of important factors, among them the various institutions and activities which contribute to national economic growth and competitiveness and to the "delivery" of new ideas, products and processes. A background paper written by experts from Finland raised a number of interesting questions.

> *"Specialisation could be a natural option for small countries, but it also entails high risks of lock-in into technologies which are outperformed or replaced by superior ones or by standards adopted on larger markets. Furthermore, however abundantly small economies invest in RTD, their investments are likely to represent only a small fraction of global RTD invested in developing the same or similar technology. For small countries, there is no point in doubling efforts when the likelihood of gaining market dominance in small, as they can easily copy and commercialise the successful innovations of their competitors. In fact, why should small countries use their scarce resources in RTD activities at all? Why not just concentrate on developing their ability to imitate and adopt technology, or at best, engage only in strictly market oriented research which holds the*

[26] In the KNOGG framework, small countries are defined as those EU Member and candidate countries with a GDP equal to or smaller than that of the Netherlands. The KNOGG countries are all so-called "small open economies", defined as price takers on international markets. Relative to larger European economies (Germany, France, Spain, the UK, and Italy), the KNOGG countries can be considered small in many respects, such as the size of the population, GDP, and trade dependency. Apart from the Netherlands, the KNOGG countries can also be categorised as peripheral within the single European market.

> *promise of results in the immediate future? Why do small country governments even provide free or subsidised education when graduates may move abroad or be abundantly attracted from elsewhere? Why invest in basic research at all? Consider-ing the technological and economic leadership of the US, do small countries even have other options than second-best follower strategies?"*[27]

In WP1, WP2 and WP3 different answers have been given to the above questions, emphasising the problems and the opportunities for the smaller countries in the global "innovation economy" Some of the national papers in WP4 raise also certain aspects of the size of the country.

The Irish national report in WP4 supports the proposition that small economies can make progress towards economic and technological convergence over a short period. It also reinforces the belief that small countries without an industrial infrastructure or technological tradition, need the catalyst of finance and expertise from outside their borders. Globalisation creates opportunities for economic expansion and can reach people and countries that were previously excluded from growth. It is difficult to envisage how a country like Ireland, trapped in a vicious circle of underdevelopment until mid-century, and lacking technology, management know-how and access to markets could have made its economic leap forward unaided. The Irish national report, reviewing the challenges facing one small country making the transition to a high-income innovation-driven economy emphasises the importance of social capital and its catalytic effect.

> *"A country can transpose the best policy initiatives, copy the best practices and commit ample resources and achieve very little if there are retarding institutional or cultural factors. Abromovitz*[28] *talks of "deeper elements of national culture that limit responses to economic opportunity". Institutions have to be flexible and open to social learning. State agencies charged with resource allocation and promoting a scientific culture must give leadership and direction and retain public confidence. Otherwise public trust in civic science will be damaged.*
>
> *Ireland, due to its late industrialisation, had very little appreciation or experience of the decisive role of technology and innovation in economic growth. Membership of the EU, exposure to its institutions and to the views of more developed economies, engendered a process of institutional and organisation learning. There were occasions where opportunities were not grasped (such as the failure to put in hand measures to improve the technology base of indigenous industry) but overall the experience was energising and positive."*

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[27] See Elina Berghäll – Jaakko Kiander – Juha Kilponen: Can small states make strategic choices in tech-nology policy? Working Paper. Government Institute for Economic Research. Helsinki. 2002.

[28] Abromovitz, M. and Paul David (1994): Convergence and Deferred Catch-up. In Growth and Development, Ralph Landau et al. (1995).

The size-specific factors are in many respects different in the Dutch national innovation system. The Netherlands is a small country that is the home base for a quite a number of TNCs. As a result the policy margin for the Dutch government are smaller than in case of a large country or a small country with no home-based TNCs. Dutch TNCs belong to the most internationalised in the world. The largest of these firms have more employees, assets and sales abroad than at home. As a result the Dutch government always takes into account the interests of the large MNEs as much as possible.

The experience of those small countries, which are on the lower level of economic development represents also a different pattern concerning the role of the size. The special problems are conditioned first of all by the relatively smaller per capita and total GDP, which influences the volume of funds spent on education or R&D. Second, the historically accumulated knowledge and capabilities in the society may be more limited. There may be also important structural problems, like the duality of the economy. The differences in the technological level and competitiveness between those industries, which are integrated into the production and supply system of high technology transnational corporations and the rest of the economy are particularly large in the KNOGG countries on a lower level of development.

From among the participants of the KNOGG project, the countries on the lower level of development are influenced also by other factors. Hungary for example had a long tradition in basic research. Slovenia has been an important research base of the former Yugoslavia. The Greek paper states that changes were not easy to introduce in Greece. The small size of the country was further aggravated by some of the recent historical determinants.[29] Only a small share of Greek corporations is in a position to conduct applied or even basic research, depending on the dynamics of the company, rather than its size and sector. It is thus suggested that research programs address only a limited number of companies, with severe eligibility criteria and mechanisms linking corporate research to investment patterns.

Even the above mentioned characteristics and problems indicate that even in the era of globalisation and regional integration small state research even in the areas of science, technology and innovations, is justified. First of all, there are many specific problems, related to their capabilities, structures, specialisation and interests. Adjustment needs to the global and regional economic realities and changes may require different policies and measures than in the larger countries. It is also important, to find the optimal proportions and structures, related to the changing conditions and the relative size of the countries. International competitiveness is also a specific issue for the smaller states. “Small is beautiful” as a concept may be relevant only in a limited scale in the era, where the large corporations determine the norms and forms of competition

[29] The civil war of the late ‘40s that divided the country and the political parties. In recent years only interparty committees in the Parliament and inclusive steering committees (at regional and national level) have started the introduction of a consensus culture. Limited manpower is a real problem in the public sector, associated with low remuneration; the private sector with few exceptions (technicians in the manufacturing industry) has no serious manpower problems and can handle internally through vocational training the shortages of the market. Funding was a limiting factor for a long time.

in the global economy. Relations between the small states and the large corporations will remain extremely important for the dynamic changes in competitiveness. Their welfare effect for the small states is also a major issue, which must be better understood. All these factors and processes are influenced by the "actors" which are not only the entrepreneurs, but the government policies and different institutions, which must be particularly flexible and open in the small countries. They are also influenced and shaped by the democratic process.

3.2 Science, technology, innovations and economic growth: theories and the practical problems of the small countries.

In the KNOGG project, one of the key issues has been the interrelation between STI and economic growth. While in general terms, WP1 has been dealing with technology as a growth factor, the other parts of the project contained also some aspects of it.

Due to the complexity of the innovation process, it is difficult to incorporate into static theoretical frameworks. While some of the eminent economists of the past centuries, from Adam Smith and Karl Marx to Joseph Schumpeter recognised and considered the importance of technological innovations in their works, the subject was ignored by the mainstream economists until the last stage of the 20th century. Many of them treated technology as an exogenous variable. Even when the problems of economic growth were considered, technical progress was treated as a "residual factor". The original neo-classical theory of the firm assumed that decisions are made by a myriad of small firms, on the basis of universally available and fixed technology, with perfect knowledge of alternatives, for the purpose of maximising profits.[30] By the end of the 20th century economic sciences increasingly accepted the idea that scientific advance and technical change are necessary prerequisites for the growth of the economy. There has been however disagreements on the exact role of technical change in economic growth. In WP1 special attention has been paid to those growth models, which have been considering technology as an important growth factor. These growth models were built by different economist at different times. They often used different categories and presented their results in different formats. The purpose of WP1 was not an academic analysis of these models or their synthesis. They were presented in the KNOGG project for illustrating the complexity of the role of technology in economic growth and for proving their importance in formulating and implementing national policies. It has been revealed that technological innovations affect economic development through a variety of intermediate linkages, within a network of interacting pressures, covering an expanding horizon of operations over an extended period of time. The process of interactions between technological innovations and the economy is accompanied by a variety of logically independent but concurrent developments. It is extremely difficult for any of the models or theories to capture the complexity of these developments. The different models, measuring technology as a source of productivity expressed in man hours, or a contributor to the growth of total factor productivity represented different aggregates. They could not serve directly the orientation of national policies. The

[30] See for example Klein, Burton H. Dynamic Economics. Cambridge, Mass, Harvard University Press 1977.

disaggregation of "technology" and the analysis of the role of product or process innovations, the importance of technology as a source of structural changes and competitiveness proved to be much more useful for business decisions and national policies. It is also important to indicate, that most of the theories did not make any difference concerning the role of technology in economic growth between large and small countries. In practical terms however the role of science and technology in economic growth and competitiveness may come up differently in many respect in small countries than for large countries.

The ideas, presented in KNOGG project are based on the conceptual and theoretical underpinnings of New Growth Theory (NGT).[31]

In the analysis of the role of R&D in the economic growth of the small countries there are a few, often raised practical questions, directly related to policies. Is there a diminishing return on R&D expenditures or expenditures on higher education beyond the "optimal" size? Is there an optimum valid for all countries or are there specific magnitudes for the smaller countries? To what extent small countries should depend on their own innovations or to what extent they are sharing the benefits of innovations made in other countries? How the costly imported innovations can raise income levels in the smaller countries? The answers to these questions are far from being simple and measurable only with indicators. There are also differences between the small countries, as it is well documented in WP2 and WP3. Competitiveness, economic success may mean different tasks and possibilities for them. The still ongoing transition process of postcommunist countries also adds differences to the issue of how to consider economic success and competitiveness in different countries. For small countries the risks are larger, since they may or may not possess the critical amount of intellectual and material properties that are increasingly required for successful

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[31] Jaakko Kiander & Juha Kilponen in a background paper written in the framework of WP1 characterise the New Growth Theory as follows: "New Growth Theory combines an old economic idea with a new reality. The theory acknowledges that ideas are the real source of economic growth and that while we must invest in ideas, many private firms cannot afford to do so. It asserts a role for government, which has the financial muscle to invest in new ideas while at the same time ensuring everyone benefits from that investment. Governments and nations have a clear incentive to invest in R&D since the welfare benefits for society are on average 4–5 times larger than the benefits an individual company can appropriate from its R&D investments. This has been confirmed by several empirical studies. The main reason behind this "discrepancy" are knowledge spillovers, which are at the core of New Growth Theory.

The crucial difference between New Growth Theory and the traditional neo-classical growth theory is that NGT emphasises the role of increasing returns to scale associated with new knowledge, while according to the old theory decreasing returns to scale would eventually impose limits to growth. Knowledge has different properties from other economic goods. Knowledge is a non-rival, and partly excludable good which can be used by many people at the same time. As a consequence, knowledge creates opportunities for nearly boundless growth. Meanwhile the neo-classical physical factors of production, such as labour and capital, restrict growth opportunities to the supply of these limited resources.

New Growth Theory rests on two observations. First, the old economic idea of diminishing returns, (which really reflects a lack of imagination). Second, while the development costs of a new product may be high, its production and distribution costs may not be, which creates a disincentive to invest in the development of ideas which can be easily copied. But new ideas and the resulting technology are proven mainsprings of economic growth today. If they are stifled by the lack of funds, government has a powerful role to play in investing in research and development necessary to ensure prosperity and sustainable growth." (Economic growth and the role of STI policy in the light of new growth theory.)

innovations. The size barriers of national innovation systems usually lead to the erosion of the already existing capacities. Human capital may be weakened by brain drain since many of the most promising research areas are not searchable because of the lack of local opportunities. This situation necessarily calls for flexible and active state STI policies that require the proper understanding of the nature of changes the character of challenges and the possible options. It has been underlined however that smallness of a country cannot be defined by a single criterion. The decisive factors could be population, area, natural sources, general wealth, and so on. But regardless of size, it is clear historically that knowledge is one of the most important factors in development. In the contemporary fast changing world, knowledge has indeed a decisive role. That is why small countries must pay attention to research and education. However, it is more difficult in smaller countries to find an-swers to perennial questions, such as “Why conduct research? How much research can a country afford? To what extent should the research be controlled?” Clearly, smallness in certain cases and areas may mean that changes can be introduced more easily, due to the smaller number of firms, the smaller costs or institutional adjustment needs involved. Yet, to directly mimic the funding percentages and structures of larger, successful countries, would be unlikely to produce the same outcomes because small countries lack the same critical mass and scale as the larger states. This problem requires a much higher degree of specialisation.[32] Even in the specialised areas there may be also many constraints – limited manpower, limited funding, difficulties of setting priorities, a small base for direct innovation, and so on. The careful consideration of strategies and programs is more important in the smaller countries, which may feel more directly the pressure of international competition.[33]

In the small countries it is even more difficult to find balance between the natural wish to expand research, the constraints due to limited funding and human resources, and the needs of the society and state is not easy. For small countries for example, striking a balance between broad research-based university education across disciplines and necessary support for a few established fields of research is even more difficult.

WP1 revealed that at the beginning of the 21st century there are new opportunities for the smaller countries provided by globalisation of information technology and international co-operation. There are no generally valid recipes however for the appropriate or optimal proportions of educational or of R&D expenditures which would have a decisive influence on the national and international sources of opportunities. There are certain thresholds in all states below which the country concerned is remaining or becoming a “technical desert”. The category of technical desert is also ambiguous. Every country has some technology obtained from the accumulated experiences of past generations. The technological capabilities must be related to the modern practices and development levels. The necessary minimum on

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[32] These problems are of course not new. They have been raised years ago. See for example: Katzenstein P.: Small States in World Markets: Industrial Policy in Europe, Cornell University Press, 1985, Ithac NY and London.

[33] Elina Berghäll – Jaakko Kiander – Juha Kilponen: Can small states make strategic choices in technology policy? Working Paper. Government Institute for Economic Research. Helsinki. 2002.

the lower level of development includes expenditures on education which can provide the level of functional literacy and of the basic technical skills for human capital formation in the three levels of the educational system, in health, in the respective branches of government and in certain technical organisations which are indispensable for public policy. In the economy those capabilities are indispensable, which facilitate the identification and use of the technology for the increase output and income.[34] The threshold of necessary minimum is of course much higher on the higher levels of development, in countries which are exposed to the forces of international competition and in the era, which is the transition to a knowledge based economy or society. On this level all the he institutions and instruments, which facilitate STI are more complex and require much higher financial and intellectual inputs.

An other interesting issue is related to the effectiveness of the relative size of public and private sources of R&D expenditures. We want to refer in this context to some very important conclusions based on the experiences of Finland, which may have general relevance for the KNOGG countries as well.[35] One of the Finish experts, Professor Toivanen underlined[36], that

1. The argument for public R&D funding is based on research results indicating much higher social returns to R&D than private returns. If most of the resulting high-tech products and innovations are exported, like they typically are in a small open economy like Finland, the high social returns actually accrue to foreign consumers of the Finnish high-tech goods. Therefore, funding policy emphasising innovations new to the market, does not make much sense for small European economies;

2. The Finnish market is so small that competition is limited and inputs consequently relatively expensive. The best science and technology policy may actually be competition policy. This may pertain also to other relatively small peripheral economies even if they are open.

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[34] Empirical evidence suggests that the long-run elasticity of output growth with respect to foreign R&D may be even higher than that from domestic R&D (Guellec et al., 2001). Coe and Helpman (1995) also find large effects of foreign R&D on domestic total factor productivity. Also, Eaton and Kortum (1994) calibrate a model of international technology transfer and find that, even for USA, around half its productivity growth depends on foreign technology improvements. This conclusion, indicating very large across-country spillovers, stems from the fact that in their sample of all OECD countries each country's share of the new knowledge generated by the group is quite small. However for this to hold, certain conditions must be satisfied. The main condition is that R&D intensities in the receiving countries are sufficiently high to allow these countries to benefit from foreign R&D: the impact of domestic R&D intensity on the elasticity of foreign R&D is positive and significant (even though existing empirical research has not determined what exactly is the R&D intensity in the receiving country that will allow it to achieve substantial benefits from foreign R&D, this is unlikely to be less than 1 %). As Guelec et.al. (2001) note (p. 113) "other countries' R&D (may) matter more than domestic R&D for the purposes of productivity growth, provided that the country has the capacity to absorb technology from abroad". Guellec, D. – B. Van Pottelsberghe: R&D and Productivity growth: Panel Data analysis of 16 OECD Countries. OECD Economic Studies. 2001. Coe D. – Helpman E.: International R&D Spillovers. European Economic Review 1995;Vol. 39. Eaton J. – Kortum S.: Trade in ideas: patenting and productivity in the OECD. Journal of International Economics 1996; 40.

[35] In a seminar on the Innovation Ecology within Global Knowledge Economy held in Helsinki on 7th April, 2003.

[36] Source: KNOGG National Workshop, held in Innopolis, Espoo, Finland 01 04. 2003.

3. Scale economies are present in R&D. In each sector there is a critical mass which sets the minimum for worthwhile efforts. Finnish R&D is less than 1 % of global R&D, and it would be exceptional luck if major technological breakthroughs were made and further converted into economic growth. The key issue for small open economies is the absorption capacity of technologies created elsewhere. A central policy to develop and maintain this capacity is to invest not only in quantity, but also in the quality of education.

It is evident that the success of S&T also in small countries depends on the appropriate combination of science and technology policy in the framework of a national innovation policy that encourages foresight programs, promotes interactions between academia and industry, and based on international co-operation. Little hard evidence is available but even in small countries there can be a diminishing return of R&D investments. The interrelations between the national system of innovations and the educational system are the strongest on the level of higher education and doctoral studies. Oversized higher education however may not be resulting in a measurable increase in the knowledge and skill level of the population. Another particularly interesting issue is the specificity of the knowledge based growth model in small countries: the influence of knowledge on the different factors of production, and on their role in the changes of entrepreneurship, incomes and wealth and in the international competitiveness of the national economic system. The very few efficiency measures of STI inputs and outputs can only reflect to certain easily measurable parts, but leave essential features covert. Important differences in the structure and orientation of scientific background institutions or different patenting principles and practice may distort these few measures. A proper criticism of the existing measurement tools leads to putting the simple question: is success and failure in R&D and the innovation system measurable on a macro level or should analysts rather concentrate on mezzo and micro level experience? If macro indicators are relevant, what should be the proper and most comprehensive method of measurement on this level? In small countries it is particularly important to study the success and failures in competition as a measurement of their position in STI. It is evident also from the practical experiences of the KNOGG countries that success depends not only on the stock of productive factors but on the capacity to create them and sustain their growth. The Contribution of the Finnish team to WP4 stated:

> *"The Finnish National Innovation System has been geared towards producing innovations to the global market place, and it has, indeed, proved rather successful in delivering them. However, more broad-based benefits for the economy in terms of productivity growth across sectors have not fully materialised. The emphasis on innovation also risks diverting the focus away from the equally important commercialisation and marketing aspects of the innovation chain. Technological know-how is the Finnish trump card also in international comparisons of real competitiveness, in which Finland has frequently scored among the top performers if not first. In these rankings, Finland's overall competitiveness is mainly due to good technology and research co-operation, technology*

development and application, utilisation of new information technology and good administration, as well as the national system of education. In addition, good infrastructure, sound policies and institutions, as well as political and economic stability are perceived to contribute to global competitiveness."

Investigating the impact of the Dutch R&D-infrastructure on economic growth of the Netherlands the paper of the team from Netherlands analyses the patents of Dutch firms. Patents can be considered as an indicator of technical improvement of products or productions processes and hence contribute to the technological innovation capability and growth potential of a country.[37] Most patents come from the private sector. Universities and (semi-)public research institutes accounted for 3.7 % of the patents acquired in the European Patent Office (EPO). Part of university research is patented through the private sector because companies that funded the research often own these patents. In that case universities receive royalties.

In the following table, trends in patent productivity are presented. Patent productivity means the number of patents per unit of input like R&D expenditures or R&D personnel. Because private firms acquire most of patents, we use as a denominator R&D-personnel in the private sector.

Recent trends in patent productivity: 1993–1998 (average score = 100).Relative number of patents per R&D-worker in the private sector

	EPO-patents			USPTO-patents		
	93–94	95–96	97–98	93–94	95–96	97–98
France	104	97	89	101	94	90
Germany	112	121	128	108	115	116
United Kingdom	57	56	58	64	67	73
United States	Na	Na	Na	Na	Na	Na
Finland	116	145	132	128	161	144
Ireland	36	40	28	60	60	37
Greece	Na	Na	Na	Na	Na	Na
Netherlands	171	156	145	176	162	140

Notes: patent productivity = number of patents in country of inventor/R&D-personnel in the private sector; NA = not available.
Source: DOST (2000).

The numbers in the table are relative compared to an average of 14 European countries (average = 100). In order to make a comparison the patents acquired in Europe (EPO) and in the United States (USA) are presented.

[37] Patents as an indicator of technological improvement have as a disadvantage that they probably under-estimate the real technological improvement because inventions are not always patented for strategic economic reasons. Moreover, small firms do often not have the means to patent their inventions.

The Netherlands performs very well relative to the average score. In both Europe and the USA the Netherlands performed more than average. In 1997–1998 the Dutch patent productivity score is 45 % above the European average in case of EPO and 40 % in case of USPTO. The relative high level have to be attributed to the fact that the Neth-erlands is a small economy, particularly in relation to the large numbers of R&D-intensive multinationals that are active in sectors in which many inventions are patented (like electronics, chemicals, pharmaceuticals, etc.). In Europe the Netherlands show the highest score.

3.3 Institutions and policies

STI policies may be interpreted as attempts to achieve simultaneously diverse social and economic goals which cannot be easily reconciled or even endanger each other.

STI policies may be interpreted as attempts to achieve simultaneously diverse social and economic goals which cannot be easily reconciled or even endanger each other.

There has been a general agreement in the WPs of the KNOGG project about the main tasks of science, technology and innovation policy. The primary task is to ensure a balanced development of the innovation system, in harmony with the main social and economic goals in the given country. These goals usually include the increase of competitiveness, the improvement of the standard of living, contribution to employment creation etc. They underline the importance of harmonisation of STI policies with other policy areas. There are a number of social actors the interests of which are directly influenced by the instruments of implementation and by the outcomes of STI policies. The main institutional aspects, mechanisms, direct and indirect instruments of STI policies in general and in the KNOGG countries have been dealt with in WP2.[38] It was underlined that the main task of the institutional hierarchy of STI policies is the development and implementation effective STI strategies, including the constant improvement of policy instruments and mechanisms. There is also a broad area of concrete tasks like the increase of the quantity and the improvement of the quality of human resources, science education and training especially at secondary and tertiary level including teacher training, developing science and technology infrastructure and improve access to S&T know-how. The STI institutions of the governments should promote linkages between universities and industries, and commercialisation of public research findings. They should help promote diffusion and reduce the barriers to knowledge transfer, promote international co-operation in STI and the national participation in international organisations and programs. An other important aspect of STI policies is related to gender: the task of improving the participation of women. Governments should also assist institutions which are dealing with the social understanding and popularisation of science and technology.

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[38] See: Cogan J. and McDevitt J.: Science, Technology and Innovation Policies in Selected Small European Countries. Government Institute for Economic Research. Helsinki, 2003.

The direct target of STI policies is not economic growth itself, but the contribution to the structural changes production, services, consumption, the growth of national export competitiveness, etc. In the environment of a market economy, the national policies often want to correct market failure. Government policies may contribute to both the supply and demand side of the STI "equation". On the demand side there is government procurement and the use of innovations in different areas, related to activities in defense, health, education, environment protection and others, financed by public sources. On the supply side governments may contribute to the increase of scientific and technical knowledge created in public research institutes. They play also an important role in the development of education. They may be source of information needed for successful research, development, production and sales. They may contribute to financial resources of firms and other institutions doing research, to the construction of infrastructure and its sustainability. Most of the governments developed a range of institutions to promote national R&D and innovations. The institutional framework in the KNOGG countries is basically similar to those in other countries.

The legislative bodies of the respective states, i.e. the national parliaments are dealing with the longer term national goals of STI. Some of them have a special committee to deal with science and technology. In the framework of the executive branch of the governments there is a high level advisory board and/or central agency involved in the planning and high level harmonisation of national science and technology policies. There are special high level agencies or departments for elaborating and implementing (financing) long term national strategies. In some of the KNOGG countries there are national academies of science, and public research institutes.

One of the main conclusions of WP2 is that a national consensus on the main targets of STI policy is a fundamental condition of its success. This is supported particularly by the Finnish experiences.[39] This would facilitate the avoiding of interruptions caused by political changes. It should be sufficiently long term, corresponding the logic and

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[39] The Finnish national paper presented in WP4 underlined: There is a national consensus on the main targets of STI policy. It has been formed gradually but also systematically through co-operation and networking between different actors of the NIS. The main political parties also share a common vision of the purpose and objectives of Finnish STI policy and the NIS. This means that political changes do not easily interrupt the implementation of long-term policies.

A fundamental feature of the NIS is the widely shared belief that international knowledge spillovers and technology diffusion are conditional on a strong domestic knowledge-base and innovation system. According to this view the NIS and public STI policies should focus on building the domestic knowledge-base. During the 1990's, the international dimension of technology diffusion was strengthened with the awareness that most knowledge and technology was bound to be generated elsewhere. A distinguishing feature of the Finnish innovation system is, however, the extent of domestic innovation efforts compared to the technology diffusion oriented strategies commonly recommended to small countries.

Alongside the implementation of the NIS – approach, the cluster concept was merged with new industrial policy. Inspired by Michael Porter's "The Competitive Advantage of Nations" (published in 1990), the Ministry of Trade and Industry introduced the concept as the cornerstone of its national industrial strategy. Although the effectiveness of several separate cluster programmes have been somewhat disappointing, the concept has revealed new promising possibilities in combining regional and STI policies to gain mutual benefits, as well as learning opportunities on the role the public sector can play to strengthen networks and provide infrastructure for more effective STI policy.

structure of the innovation process. Consensus can be formed gradually and systematically through co-operation and networking between different actors of the NIS. The role of the Government as an investor, a catalyst, and a regulator has been defined and analysed in a comparative perspective.

National institutions and mechanisms for the creation of factors promoting STI are however rarely in themselves a source of competitive advantages. It is also necessary that governments should be able to support national competitiveness in a cost effective way and their policies should be relevant.

An other important conclusions of WP2 are, that there can be different institutional forms in STI which may result successful policies. Success or failure is usually the result of several factors and their interactions, including the external environment. This work package analyses role of the governments in the financing of STI, support for investment in installations and equipment; institutional development; training and updating of scientific and technical personnel; running costs; diffusion and promotion; education for science; scientist setting-up of networks and communications systems, etc. The analysis of financial instruments revealed that not all of them, new or traditional, are equally adequate to finance all the activities which jointly, favour high quality. Certain instruments or funding mechanisms used in an inappropriate manner can have a negative impact not only on scientific activities as such, but also on other areas such as higher education. The effectiveness of the competitive funding mechanisms may differ in many respects widely across countries, general conclusions may apply to various extents to each individual country. Some of the lessons may be useful to policy makers. First, well-designed government programs have a leverage effect on business R&D. Second, frequently redesigning a policy instrument, e.g. the rules and generosity of R&D tax credit or government programs – reduces its effectiveness. Third, a piecemeal approach to such instrument of technology policy as tax breaks or direct funding is detrimental to its effectiveness. Fourth, direct funding of basic research is a very important instrument only if it is long term, predictable, and relevant. Fifth, the various policy instruments should be consistent with each other, which implies that the various administrative departments involved in their design and management need to be co-ordinated.

Developing multiple-effect financing mechanisms, which can finance specific research as such and also training of personnel, diffusion and international mobility may be also feasible. As far as R&D is concerned, the state should in part guarantee the freedom of research and the proper conditions for innovation in the society. The state should be particularly active in those fields where capital is less available. It follows that the state must take care of education and training, professional manpower supply and further training, and must see to it that the institutions necessary for innovation are properly financed, at least to the level of basic provision. And it should also provide for basic research as well as for applied research which is not supported by the business sphere. A consensus needs to be reached between the different sources of policy formation. Flexible funding with multiple sources (governmental, private, international) must be encouraged to meet the needs of society, guarantee stability of research, and foster innovation going. Presently, international funding of S&T in small countries is relatively small, as is funding from non-public funds. Mechanisms for increasing these need to be explored. The weak points of many smaller countries, especially of those in the transition stage are – the existence of old-fashioned science structures, rigid funding schemes, weak administration, shortage of qualified (young) scientific workforce. These can be ameliorated through a strategic system of priority setting, regional and global co-operation. One of the very important conclusion, which can be drawn from WP2 is that STI are an integral part of modern social and economic development which implies a much closer relationship between policies for science, technology and innovations and other areas of national policies also in the smaller countries.

3.4 The role of the international corporate sector

Firms are the key actors of international competition in the global market. Competitiveness is increasingly dependent on the ability of firms to use and develop new technology effectively. Access to the new "core technologies" has become crucially important to international competitiveness. Technological development on the level of the firms depends on internal and external factors. The external factors include the interactions with other firms. Particularly with those which concentrate global technological capabilities. *The transnationals are crucially important members of the international R&D hierarchy.* An UNCTAD report noted, 'The transnational corporate systems are well suited for technological innovations, because they have easier access to financial resources, an ability to tap the global market for scientific and technical personnel, and the ability to organise R&D and utilise technological assets world-wide.'[40] *Research costs have also risen substantially*. The chances of using new techniques are wider than they were, extending to the whole chain of production and utilisation, and to various branches. This can be exploited particularly well by diversified international corporations, integrated vertically or horizontally. *The specific role that transnationals can play in a country's specialisation based on scientific and technical development depends on the competitive strategies they adopt, and on the "receptiveness" of the host country.* It became of key importance in high-technology branches of industry to ensure that the group gained a commanding world position in certain segments. The strategies for gaining technical leadership on a global scale called for high R&D spending, frequent acquisitions of competitors, concentration of resources, and integration of the related services. Transnational corporations either sell the new technology in a simple, one-off transaction, or try to retain a technical monopoly within their system, spreading their innovations through their affiliates abroad. The delay before innovations reach a subsidiary, or the degree to which they do so, depends mainly on the latter's role in the group's global strategy and the technical competition in its home market. The explanation for a rise in turnover between the parent and a subsidiary may be financial artifice. In many cases, however, the reason why a transnational makes a product at more than one site is technological dependence between firms, or differences in cost relations between them. Analyses of turnover within transnationals suggest there is a correlation with

[40] UNCTAD (1995a) World Investment Report, p. 149.

R&D. The importance of intra-group commercial transactions rises in line with the intensity of its R&D. Intra-group payments for technology (royalties, licence fees, etc.) have risen faster than other internal transactions.

The transnationals influence the regional distribution of various branches of manufacturing in different ways, due to their different innovation features. Transnationals normally site manufacturing of traditional consumer goods (textiles, textile garments, leather wear and footwear, printing, wood) in less developed countries. There they combine cheap labour with peak technology, which can multiply their profits. Industries requiring economies of scale (vehicles, sections of the electronics industry, metalworking, foodstuffs, parts of the chemical industry, glass making, building materials) are important to countries at a medium level of development, and in some cases to international integration of their production. The R&D of transnationals is becoming internationalised in a specific way. For a long time their strategic development work was confined almost entirely to the home country. Subsidiaries would work largely to full documentation received from the centre. This is still the main direction of flow. However, as globalisation causes the transnationals to shed some of their national character and affiliations, this applies also to creative inputs, such as R&D, not just to applied strategies. R&D has been included in the global sourcing system. Transnationals have been encouraged by cost factors to set up foreign laboratories to conduct some of their research and testing. Nonetheless, the bulk of the R&D remains in the country of the transnational's parent company, so that its R&D role in international specialisation enhances the home country's competitive advantages. The conduct of R&D abroad tends to follow investment there. It is still rare for cheaper, foreign R&D capacity alone to attract direct investment. Far more characteristic is for the parent company to shift the less strategically important components of its R&D abroad, but to keep them integrated into the operations in the base country. The large transnational corporations own most of the production technologies available in the world. They are therefore the main technology suppliers to all countries. In the early 1990s 80 per cent of the total receipts for technology supplied by the US was on the account of TNCs. In Europe, the proportion of TNCs was 50 per cent in the total receipt for technology.[41] During the 1990s there was a fundamental transformation of the international investment regimes: first, there has been not only an extraordinary increase in the volume of FDI flows and stocks, but there was also a spatial change, toward the former socialist states. Most of the increased flows resulted in a much higher concentration of TNCs in high technology global production, due to mergers and acquisitions and strategic alliances. This process was particularly important in the European Union and in the United States. There has been an other important change, the emergence of the "innovation-network model" in most of the high tech industries. with feedback loops and research spillovers.

The growing importance of global sourcing of *R&D capabilities is also an element of this new strategies.* Despite the increase of their external sourcing activities, heir STI activities remain concentrated in their home countries. Many TNCs at the same time

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[41] J. J. Salomon and others: The Uncertain Quest. Science, Technology and Development. UN University Press, Tokyo, 1994. p. 384.

are doing more research abroad and are integrating also certain parts of the innovation-production system across national frontiers. For a number of corporations acting on a global scale, globally located competence centres are gaining in significance. International leaders in high tech are pursuing a strategy whereby their R&D and product development are situated wherever the world's best conditions for innovation and knowledge generation exist for their particular product segment or field of technology. They are not content with locations just about able to keep up in the technology race but seek out those centres of excellence with a character of uniqueness. A number of TNCs outsource certain parts of the long-term research to foreign research laboratories, universities and to smaller high-tech companies, which are strong in a special technology niche. Research consortia and networks are created. This includes some of the smaller countries in Europe with strong international engagement of scientists and industry. It is of course evident that there is a limit to how much can be outsourced. Most of the large firms maintain the core of STI at home.

In the small countries the role of transnational corporations is particularly important, because of their role in STI and the international diffusion of innovations. The role of transnational corporation in the development of STI capacities is also related to government policies and institutions through a number of channels. This is reflected both in the analytical part and in the conclusions of WP3 which has been dealing with the role of the corporate sector and particularly with the role of TNCs. The conclusions of WP3 underline that the relationship between small European countries, foreign direct investment and technology development is complex. The greater openness of small countries to FDI as compared with large countries makes FDI an important mechanism to increase the knowledge base of small European countries. Small developed countries are squeezed between two developments. First, the growing complexity of new core technologies and limited resources impede the development of an extensive R&D infra-structure. So-called national treasure R&D is hard to achieve in small countries.

The other development is that competition in low and medium technology products is increasingly dominated by the Newly Industrialising Countries. This suggests an increasing technology gap between large and small developed countries. At the same time technology has been increasingly internationalised in the last decade. The way out of this squeeze for small countries is to make optimal use of the internationalisation of R&D, which offers many opportunities for small European countries to upgrade their knowledge base if they implement the right policies. The conclusions of WP3 state:

> *"For small European countries it is necessary to attract the high-technology parts in order to upgrade their technological knowledge base. Therefore it is of importance for small countries to construct national innovation systems (NIS) that stimulate the tech-nological strengths of domestic firms. Such firms are important attraction factors for foreign R&D intensive MNEs because the later will invest for reasons of strategic asset seeking. Financial incentives purely aimed at attracting R&D intensive FDI*

to small countries is necessary but insufficient. They have to be supplemented with policies that stimulate learning and investments in domestic firms. The essence of high technology parts of MNEs is that they produce knowledge with positive externalities, which they will only share with other firms or S&T institutions if they receive something for it in return, such as new knowledge from domestic firms. Therefore countries with a high scale of technological activity like Finland are in a better position to attract MNE affiliates with R&D facilities than countries like Ireland or the Netherlands with a lower scale of technological activity."

In this paper we refer the patterns and policies in some of the KNOGG countries, which indicate the problems involved.

The Netherlands is a small country that is the home base for a quite a number of TNCs. As a result the policy margin for the Dutch government are smaller than in case of a large country or a small country with no home-based TNCs. Dutch TNCs belong to the most internationalised in the world. The largest of these firms have more employees, assets and sales abroad than at home. As a result the Dutch government always takes into account the interests of the large MNEs as much as possible.

Firm's R&D-intensity in the Netherlands in the period 1990–1998 has deteriorated relative to R&D-intensities of the OECD countries The reason for reduced R&D-intensities of firms can be attributed for 45 % to the Dutch specialisation in sectors that are not very R&D-intensive and for 55 % to decreasing R&D-expenditure of Dutch firms compared with firms of the other EU KNOGG countries. Moreover the R&D-intensity of Dutch high-tech industry seems likely to remain lower compared with many other countries (Ministry of Economic Affairs, 1995). Productive investment capacity leaks away to other countries, without appropriate compensation by leakage from other countries to the Netherlands. According to expert views, quoted in the Dutch national paper in WP4 there are a number of issues under dispute on which an intense debate is necessary.[42]

Finland represents an other interesting case. Despite successful efforts of diffusing technological knowledge and developing a diverse company base, the critical mass for the top global technological leadership still comes from one company and its network, Nokia. In 2001, Nokia alone accounted for 45 % of corporate R&D in Finland. At the

[42] Some of these are: the lack of a systematic and focused innovation policy in order to tackle the lack of industrial and innovative dynamism in the Dutch economy. The Dutch government proved to be strongly vulnerable for "picking winners" because it did so in the 1970s with old outcompeted industries like ship-building. This policy cost millions of guilders and could not eliminate the loss of employment. Therefore it is a taboo to talk about stimulating high-tech industries. The policy of wage moderation that exists since 1982 benefits the large home-based MNEs. provoked also a fierce debate. It was blamed for the lack of dynamism of the Dutch economy. It was argued that relative low labour costs hamper technological development as firms are not encouraged to invest in new more productive capital goods. An other problem, the low innovative ability and dynamism of small Dutch firms can be attributed to a lack of powerful domestic purchasing power. It is suggested that the elimination of wage moderation policy can increase the innovative power of small and medium-sized firms in the Netherlands, which makes its economy less dependent on the large MNEs and therefore less vulnerable for the "black investment hole" and hence a "race to the bottom" in policy competition.

same time Nokia represented 75 % of R&D performed by Finnish companies abroad. It is noteworthy however, that a large share of Nokia's research signified merely the usual new product development related work, and that despite its size, Nokia's R&D is not the most internationalised among Finnish companies.[43]

Finnish companies perform more R&D abroad than foreign companies carry out in Finland. Case studies suggest that about one fourth of R&D activities of all Finnish companies to be found abroad. The 19 largest companies accounted for 90 % of R&D abroad, and 30 % of the R&D personnel of these companies worked abroad, while the average figure was only 7 % for the other companies surveyed.

Two thirds of R&D activities abroad were located in the EU in 1998, although the US was the single more popular host country with 27 % of R&D abroad. The metal and electronics industry dominated the scene, employing 80 % of the R&D personnel abroad.[44] In 2001, USA, Sweden and Germany were the most popular host countries.[45] Large companies' R&D activities abroad are integrally linked to the companies' other R&D activities. R&D networking emerges as the preferred mode of organisation. These networks may include suppliers, clients, research institutes and even competitors. Co-operation with clients and within the network of the R&D unit abroad has increased rapidly in recent years.

Finnish companies are not, however, transferring their R&D activities abroad. Overseas R&D outlets are often by-products of foreign acquisitions, rather than explicit strategy going beyond the usual product development and market monitoring. The acquisition of foreign units by Finnish TNCs has not reduced their R&D investment in Finland, which appeared to have maintained its advantage as a location in terms of cost and quality.

Foreign firms have used acquisitions to gain access to Finnish technological capacities. Technology sourcing raises the risk that foreign companies merely transfer knowledge gained in Finland outwards. The evidence on FDI generated technology inflows has been weak, and in balance the verdict may even be negative for knowledge related spillovers at least as far as asset-seeking has motivated inflows in the purely technological sense of the term. It is also questionable to what extent foreign companies' R&D in Finland should be supported by public funds. Still, foreign firms in Finland generally innovate technologically more than domestic firms, and may hence contribute to knowledge intensity in the Finnish economy.

Public support of foreign companies may, however, make sense when the incoming firms complement local technologies and skills. There is little hard evidence on spillovers, but most of the indicators suggest foreign companies to produce more positive externalities than domestic ones.

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[43] Lovio, 2002.

[44] Pajarinen & Ylä-Anttila, 1999.

[45] Lovio, 2002.

Typically FDI is highly concentrated in certain clusters and agglomerations enjoying high rates of economic activity. This is the case in Finland also, and hence potential spillovers are likely to have been to a large extent confined to certain regions. These regions also experience higher competition for inputs, including labour and human capital. Also costs are generally higher in these areas. Yet, such regions manage to attract more and more companies since they also offer fruitful conditions for innovation, in addition to the inputs necessary in various types of economic activities.

Ireland does not constitute a large market in the context of global FDI, and the majority of incoming FDI companies export all or a predominant share of their output. Nevertheless Ireland's membership of the EU means it can satisfy the market-seeking requirements of non-EU companies, and this is a key consideration in the case of its large US-owned contingent of MNEs.

A second motivation of inward FDI to Ireland is efficiency-seeking. The combination of Ireland's comparatively low wages and FDI incentives offers significant cost-saving opportunities for MNEs.

Technology sourcing is not a significant motivating factor. The education and skills of the workforce are highly prized but MNEs do not seek out Ireland specifically because of local technology expertise in its research institutions. Technology exploitation is the quadrant that describes Irish inward FDI. The essential question of interest here is to what extent TNCs are linked into the Irish system of innovation? This is an important question because Ireland has championed the FDI route to economic development.[46] Ireland has done this by successfully targeting selected high technology industries such as pharmaceuticals and information and telecommunications technologies, and is now a world leader in the proportion of its exports that are classified as high-tech.

Ireland's technology policy, like that of its fellow Community members, is founded on the concept of improving innovation capability and upgrading the national system of innovation, on the journey towards a common EU "research area". There are a multiplicity of ways in which TNCs can enhance the innovation potential of the host country. They can make an important contribution to its research system through R&D spillovers; they can incubate high-tech spin-off companies; they can act as conduits for the transfer of codified and non-codified technology through human resource mobility and intensive-interaction with the indigenous sector; and they can stimulate the creation of networks of suppliers of high value-added products, components and services to supply foreign-owned industry.[47] The limited empirical data that is

[46] Mjoset, Lars (1993): The Irish Economy in a Comparative Institutional Perspective. NESC Report No 93: Dublin – "Since the late 1950s Ireland has tried, in effect, to import a system of innovation through FDI."

[47] These benign effects of FDI are contingent on the existence in the host economy of what Abramovitz called "social capability" and "technological congruence". Pain (1997) cites the finding of the Borensztein et al. (1994) study of FDI flows from industrial to developing countries – the impact of FDI on growth is dependent on the existence of adequate human capital in the host economy.

available, however, points to a very modest contribution by TNCs in all these areas to the development of Ireland's indigenous innovation capability.[48]

Ireland's foreign-owned sector, for the most part, operates in a global system of production and innovation and does not contribute to the resource base and linkage dynamic of the domestic innovation system. Interactions that build up national technological capability include inter-firm technical co-operation, user-producer and sub-contracting linkages as well as commitment to R&D and other intangible investments. A deficit in all these areas characterises the operations of foreign-owned firms in Ireland. This reduces the externalities on which indigenous firms can build and it leaves a vacuum in the national system of innovation.

Hungary has become one of the most "transnationalised" countries in Europe. In 1999 the "transnationality index" calculated by UNCTAD, (which is the average of four shares: FDI inflows as a percentage of gross fixed capital formation for the past 3 years, FDI inward stocks as a percentage of GDP in 1999, value added of foreign affiliates as a percentage of GDP in 1999 and employment of foreign affiliates as a percentage of total employment in 1999) was 27, the fourth or fifth largest in Europe, after Belgium-Luxembourg, Ireland, Sweden. It similar to the index of the Netherlands. The share of foreign affiliates in the total exports was 80 per cent. In Hungary there have been two main ways of technology sourcing: employing highly qualified specialists and acquisition of companies of existing and prospective R&D units, laboratories and know-how. As for human resources the advantage lies in the relatively high level of natural sciences education in the secondary and tertiary education. Getting the control of already existing R&D units and laboratories has been the other way for technology sourcing. The pharmaceutical industry is clearly an area to mention here. Case studies show that a wider scope of R&D activities can lead to a deeper co-operation with suppliers. The time lag of starting R&D after the initial investment is shorter in these cases.

Foreign firms in Hungary have been playing a very important role in the technological upgrading of a few industries which are playing a strategic role in the export of the country. This has influenced research and development, product and process technology, design, organisational practices and training in the given industries. The TNCs in Hungary however do not have many linkages with the domestic suppliers or sub suppliers. Many Hungarian firms were acquired by TNCs during the privatisation policies of the 1990s and given a specialised production place in the global production network of the TNCs, who used mainly their own suppliers and did not switch to Hungarian suppliers. However, in the course of time – after having learnt how the Hungarian business environment works – more use is made of Hungarian suppliers. These are channels for R&D spillovers to domestic firms although at a level below the technological capability of many Hungarian firms. Through FDI new forms of management and organisational methods have been imported as well. They are aimed at increasing productivity and efficiency. This is also regarded as new knowledge

[48] Mjoset, Lars (op. cit.): "FDI failed to generate sufficient spillover effects to create an organic, selfsustaining Irish system of innovation."

transferred through training and everyday practice. This kind of knowledge is easier to be transferred, less of a secret and can be easily utilised in other industries as well.

Attracting new investments for stimulation the local R&D of the affiliates of foreign firms and for providing skilled and better-paid jobs is a legitimate goal for the governments in the KNOGG countries. It is essential however to strengthen simultaneously the STI framework for local business and to identify mechanisms for a more efficient innovation process, to create incentives for spin-off companies from knowledge centres at universities and larger companies. One main element in such policies is to have a strong local R&D infrastructure including the university system. Many channels for collaboration between international and national firms and universities on research already exist. These have helped to build up new competencies in companies. Relations with the TNCs is and will be particularly important for the accession states. EU membership will create new and in many ways improved opportunities to use the TNC sector for upgrading their STI capabilities.

3.5 Toward the European Research Area: perspectives and problems

The role of the European Union in promoting complex and comprehensive co-operation between countries, national and international firms, national research centres universities will be more important in the future. It will influence all the main actors in STI. In order to achieve the anticipated goals, the European Union and its present and future member states will have to implement important policy changes, in a number of areas. One can agree with the following introductory statement of an important EU document

> *“Achieving an innovation performance that makes the European Union a world reference for innovation represents an enormous opportunity that can translate into raised living standards over the coming years. Progress towards such a more innovative Euro-pean economy is however proving tentative and fragile. Enhancing innovation is a cornerstone of the strategy to meet the target agreed by the European Council in Lisbon in March 2000 of the Union becoming the most competitive and dynamic knowledge-based economy by the end of the decade. Yet the Commission’s 2003 Spring Report1, which assesses progress towards the Lisbon goal, stresses that much remains to be done, particularly in the area of knowledge and innovation signalled as the central priority for the coming year in taking the Lisbon strategy forward”.*[49]

International collaboration in research, involving universities, research centres and industry, has long been supported by the European Union (EU). Since its earliest days, the EU has had to justify its actions in terms of the additional value they might have over the actions of Member States. The positive reasons to collaborate are fairly

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[49] Innovation policy: updating the union’s approach in the context of the Lisbon strategy com(200in3) 112 final commission of the European Communities, Brussels, 11.3.2003.

obvious. First, progress is fastest and most cost-effective when it draws upon knowledge wherever it may be found. The experience at the European Laboratory for Particle Physics (CERN) shows that when you put together scientists and engineers who have been trained in different traditions and look at problems from different points of view, often the whole is better than the sum of the parts and they come up with original ideas for solving problems. Second, many areas of research require broad interdisciplinary approaches and international collaboration may be essential in order to reach the necessary critical mass. Third, there are some activities that are beyond the means of most – in fact probably all – individual countries, so that if we want to do this research we must collaborate. Furthermore, even if an activity is affordable nationally, international collaboration may be desirable in order to reduce costs and avoid duplication. Finally collaboration has a valuable human and political role in bringing people together, which it is appropriate to emphasise. Co-operation has been organised since 1984 within successive multinational framework programs. Community research activities are designed to complement those of the EU's Member States and work towards closer integration of Europe's scientific and industrial communities. The central objectives of Community research policy are to reinforce and mobilise the Union's scientific and technological capabilities in support of industry, the economy and quality of life. The Fifth Frame-work Program (FP5, 1998–2002) broke with tradition in targeting resources on specific socio-economic objectives, by means of focused research actions of an integrated and interdisciplinary nature. The approach became more selective than the science- and technology-driven approach of the past and will favour partnerships and networks of research actors – public and private – which are more strongly oriented towards utilisation and uptake of results. As the main foreign direct investor, the largest world market and the biggest purveyor of development aid, the Union is poised to play a major geo-economic role in which the Research and Technological Development (RTD) policy will be instrumental in mobilising S&T resources to reinforce pro-actively European international competitiveness.

> *"The European Union has clearly stressed the importance of science and technology policy and emphasised it in the Framework Programs. The main aim is to put S&T into the service of the community of Europe. In addition, national problems of ensuring intellectual power and establishing national priorities are crucial issues. Despite the differences among the countries, many issues, such as the effectiveness of research structures, competitiveness of the grant market, training of a new generation, financing structures, impact on society, and others have common features. The existence of a well-defined S&T strategy and its recognition by the governments and parliaments makes a basis for normal development. The targets of such strategies will be politicians and the community as a whole. The national evaluations of the framework programs offered certain conclusions. The Finnish WP4 report for example stated."*

An impact evaluation can only be found for the Fourth Framework Programme, which ended in 1998. This was, in fact, the first Framework Programme in which Finnish organisations participated on equal terms. The evaluation was based on a large survey (955) among the participants in the Program. The evaluators found that

* commercial benefits did not materialise as fast as expected, and the immediate benefits were related to such indirect impacts as learning, knowledge, resources, and networking effects.
* Project success was related to being well acquainted with project partners beforehand, as well as the project being given strategic importance in the institution carrying it out. The strategic importance had to be reflected in the status of the co-ordinator of the project.
* Participation in the Program encouraged firms to cooperate more than usual with universities and research centres. Partly this was due to the program attracting participants with previous experience in public-private co-operation.
* An important value added came from the promotion of cross-sector and cross-country collaboration. Particularly horizontal co-operation is rare between companies, while mixed networks of horizontal and vertical co-operation where the most complex to manage. Mixed networks were prevalent in standards development and in information technology and telecommunications related projects.
* Projects in low R&D intensity industries had the highest payoffs.

Various public sector institutions, such as ministries, municipalities, hospitals, education institutions, or private non-profit organisations, representing generally end-users of research findings did not benefit from the EU projects effectively. They were more often newcomers to the projects, less able to exert influence on the orientation of the research and project execution and the strategic value of the project was often low for them.[50]

The Irish national report in WP4 underlined the fact, that Ireland’s membership of the European Union has contributed to major advances in the economy and in the enterprise sector. Together with supportive domestic policies, EU membership has facilitated strong economic growth, particularly in the 1990s, and convergence with per capita income levels in the EU. Per capita GDP in Ireland increased from almost 59 per cent of the EU average in 1973 to almost 114 per cent of the EU average in 2000. The associated transfers of financial resources and knowledge and the introduction of EU policies and disciplines in the areas of competition policy, macroeconomic stability, the labour market and market opening have encouraged modernisation, diversification and the global integration of the economy. They have also helped develop the scientific base, improve working conditions and promote regional and social cohesion. Equally, the growth and diversification of Ireland’s trade and investment has been strongly encouraged by EU membership.

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[50] Luukkonen, Terttu and Sasu Halikka, 2000: Knowledge Creation and Knowledge Diffusion Networks. Impacts in Finland of the EU’s Fourth Framework Programme for Research and Development. Publications of the Finnish Secretariat for EU R&D 1/2000, Helsinki. Tekes & VTT.

Ireland has been a participant right from the beginning – Framework I in 1984–88. Fitzpatrick (1990)[51] found that participation was initially largely limited to the public sector, and within this sector to a limited number of organisations. In the second framework program participation of the private sector had increased, and most participating firms claimed that their Framework projects led to new products within three years. The fourth framework program was even more successful for the Irish economy. The impact of FP4 on the academic research base was particularly marked. The Irish tertiary sector has been extraordinarily dependent on FP4 and earlier Framework Programmes for research funding.[52] Technopolis stated that, in a very real sense, the current strength and even the very existence of the university research community in Ireland could partly be attributed to its involvement in successive Framework Programmes. The participation in the fifth program however was very disappointing, mainly for domestic reasons.

The role of the framework programs has been even more important for Greece. Greek research teams have been participating to Research Programmes since Greece joint the EU in 1981. Since that time the support by the framework programs has been a major source of funding, as it is reflected by the Greek national report to WP4.

The possibilities to participate in the framework program under the same conditions as the member states have been possible for Hungary only in the fifth program. By and large the participation was favourable, even though its financial balance was not quite up to the expectations. The participation proved to be more difficult than expected for a number of reasons: the bureaucratic procedures, the difficulties in organising consortia, the lack of experiences, etc.

From the above experiences one can draw an important conclusion, related to the absorptive capacities. The Framework Program, with its additionality and emphasis on excellence, poses a series challenges for countries whose absorptive capacities lag behind. Of particular importance here is the capacity of the economy and society to absorb and productively utilise new knowledge, science and technology. Assuming that a country is successful in competing for Framework Funds (which is not easy in areas of institutional weakness), the question of the magnitude of the benefit that the country draws from the research becomes very important. It is all too often that research institutions join European networks of knowledge creation that lead to exploitation in localities with the right kind of absorptive capacities and away from the location of the research performance. Experience from Greece and Portugal shows that pressures to absorb regional development assistance in research-related infrastructures contributes to this type of situations. Strategies for aligning local research concerns with European concerns should consider the needs and aspirations of local industries.

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[51] Fitzpatrick and Associates (1990): Review of the EC R&D Framework Programme in Ireland 1984–88.

[52] One of Technopolis's recommendations was to provide more funding at national level to academics in order to lessen their dependence.

In 2000, the Commission of the European Communities has launched the document "Towards a European research area" and defined the main ideas of organisation of research in Europe. The following excerpts from this document characterise this view:

> *"However, the principal reference framework for research activities in Europe is national. Funding of the various initiatives of European Community or intergovernmental scientific and technological co-operation does not exceed 17% of the total public expenditure on European research."*
>
> *"... the European research effort as it stands today is no more than the simple addition of the efforts of the 15 Member States and the Union. This fragmentation, isolation and compartmentalisation of national research efforts and systems and the disparity of regulatory and administrative systems only serve to compound the impact of lower global investment in knowledge."*
>
> *"It cannot be said that there is today a European policy on research. National research policies and Union policy overlap without forming a coherent whole. If more progress is to be made a broader approach is needed than the one adopted to date. The forthcoming enlargement of the Union will only increase this need. It opens the prospect of a Europe 25 or 30 countries which will not be able to operate with the methods used so far."*

Given this, a vital question arises: how to progress towards a better organisation of research in Europe as a whole? "The idea is to create a European research area." It is clear that all the national strategies of research play an important role on the European stage. Only by strengthening the research potential at a national level can the goals of a European research area be realised to their full potential.

It states three interrelated objectives:

1) To integrate European research.
2) To structure the European Research Area, by developing its institutions.
3) To strengthen the basis of the European Research Area through different channels and by using various instruments.

The framework programs and the creation of the European Research Area have been and will be changing the RTD policy scene in Europe.[53]

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[53] The progress toward ERA has been a gradual process. 1950s/60s – CERN, EURATOM, ECSC, Agriculture, JRC, limiting Brain Drain to the US. 1970s – S&T policy resolution and five year programmes from 1977 in Energy, Raw Materials, Environment, Living and Working Conditions, Services and Infrastructure and Industry (including ICTs and Transport). In the 80s – ESPRIT; 1st and 2nd Framework Programmes; precompetitive, collaborative R&D; S&T policy tied to Industrial Policy; focus on ICTs, industrial technologies, biotechnology; other research in energy environment, agriculture etc. In the 1990s – 3rd, 4th and 5th Framework Programmes; fewer thematic programmes plus key actions and horizontal programmes; shift towards social goals; European

There are some important lesson, learned from the past experiences of European co-operation schemes. First, although it is nice to start international collaborations on green-field sites – so that everybody comes in on an equal basis – there are advantages in using an existing laboratory, incorporating the existing infrastructure and, even more important, using existing human resources. It is hard to set up big laboratories and make them work, and there are big advantages in basing new projects in existing centres of excellence with the necessary expertise. It certainly makes it easier for others to come in if the host nation or region contributes existing facilities and agrees to bear the long-term consequences at the end of the project. Second, collaborations work best when they are driven bottom-up by the scientists involved. Third, experience from the cohesion countries shows that drastic increases in R&D investment are not straightforward. The increase of R&D is limited not only by the scarcity of financial and human resources but also by organisational, institutional factors, like the administrative capacity. Contributions should be negotiated as early as possible in a project in order to involve everybody as real partners having a say in the design and orientation. Deciding to do something in one country or region then inviting people in afterwards is not likely to work. It is essential either to involve people before project approval or to offer them added value if they come in later, at least if an open-door policy is adopted. Countries with fewer scientific resources or less scientific capacity need to be better integrated in the information flow within the scientific community in order to get access to the most advanced institutions. The increasing cost of journals and books limits the accessibility of scientific information in such countries. Fourth, to make a real partnership, the host region or country should offer others a proper voice in policy decisions, possibly out of proportion to their financial contributions, even if this seems rather generous to authorities. In considering reciprocal scientific collaboration, it is an illusion to seek what is sometimes called "detailed balance". Fifth, it is very important from the very beginning to understand: what will be the "value added" in co-operation. The concept of European value added has been understood such a way that the value resulting from EU support for RTD activities should be additional to the value that would have resulted from RTD funded at regional and national levels by both public authorities and the private sector. Sixth, networks are crucially important form in STI co-operation. ERA also promises to change the practice and organisation of RTD itself, through higher budgets, higher concentration of competencies and more co-ordinated national programs. At the same time the ERA has a pivotal role in the process of EU enlargement. As in the other policy-making arrangements at European level (CREST, High Level Group on benchmarking, mapping of excellence, and opening of national programs, etc.) a key element of ERA is more the emphasis on networking than on new "institution-building". It is generally understood the ERA will be beneficial for European science only if there will be an effective process of science and innovation policy "harmonisation" in Europe resulting in the coherence of Community and national funds and will move towards the target of GERD as 3 % GDP in 2010. (It would be necessary to examine the implications of these for the smaller countries.) Seventh,

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Paradox; Innovation emphasis in 2000s – FP6 and ERA; new instruments; co-ordination; shift from allocative to structuring mechanism.

International education must be an integral component of STI co-operation. This should be encouraged particularly on the level of the universities and in doctoral and post-doctoral education. Eights Europe clearly needs a proactive policy aimed at greater overall cohesion in science and technology. The diversity of national and European scientific institutions, which is due to different historical, economical, cultural and geographical background should not be uniformalized however under the slogan of a European science policy. Any in a premature and haphazard effort toward this direction would endanger the quality of research; the readiness of networking and co-operating. The countries of Europe as it is also reflected in the KNOGG project face different problems and tasks in developing their STI capabilities. The diversity of each country may even be an asset which makes it possible to implement widely differing modes of operation and management in the research field, geared to multiple needs, and which should pave the way for all-European co-operation. A user-oriented incrementalist model of ERA could be served by different national institutions for a long time to come. Nineth, a problem which needs to be addressed also in the context of ERA is a particular form of international migration the migration of scientists which is the result of poor working conditions, lack of resources, scarcity of jobs, unstable institutional and governmental support for science and technology, as well as lack of incentives to scientists and science students, etc. The fundamental question for the small countries is however: to what extent will their participation in ERA reduce or eliminate those disadvantages, which are size specific in their STI system?

4. The national system of innovations and the sources of success and failures in national STI policies

The concept that differences between the countries in size or in structure, matter as factors among the causes of success and failures of STI policies matter, has been challenged by some experts on the grounds that transnational corporations are the main sources of innovations, and they swallow most of the R&D capacities.[54] Against these ideas, Michael Porter, the "father" of the concept of competitive advantages argued, that competitive advantage is created and sustained through a highly localised process. The national innovation system is the main structure for creating skills, developing and implementing STI policies.[55] While it is evident, that the situation may be quite specific in most of the smaller countries, including the KNOGG participants, the most of the sources of success and failures in STI may be similar to the larger countries. They may be rooted in the system of microeconomics, in the market or in the production process or in macro-policies. For many decades, most of the empirical literature dealing with successes and failures has been dealing with the microeconomic factors and processes. They traced the direct effects of micro-decisions. The analysis of macro-policy decisions in STI, how they are shaped in the government structure, what specific interests are involved and how they influence the effectiveness in the national system of innovations, are more recent. The macro-analysis has been stimulated by the important role of governments in STI and it has been facilitated by the rapid progress of indicators. In fact, different "innovation models" developed and there are also diverse policy models for the governance of the national system of innovations.

4.1 Specific models of STI policies more or less conducive in promoting successful technological transformations in a small country

The differences in size, development levels, R&D capabilities and policies demonstrate the diversity of the countries and influence also modelling. We do not intend to offer any optimal policy model in the KNOGG or in other countries. "Systemic models" may however help us to understand the special cases, factors and linkages influencing the innovation policies and reflect the ways in that innovation policy is devised and implemented.

On the basis of the main characteristics, goals and instruments of policies one may identify a few models for the governance of the national innovation system.[56] The concrete goals of policies can be different in the framework of the models. One dimension of the strategies is related to the climbing of the countries on the ladder of

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[54] See for example K. Ohmae: The Borderless World, New York, Harper, 1990, p. XII.

[55] M. Porter: The competitive Advantage of Nations, New York, Macmillan, 1990. p. 19.

[56] A few of the participants in KNOGG suggested, that we should not call them "policy models" but policy dimensions. In fact however within the different models there are political, macro and microeconomic, legal and institutional dimensions which may be contrasting or converging.

the international technology system.[57] The models of the STI policy process are of course reflecting the national policy system, which influences the role of different actors and the character of their interactions.[58]

Model 1.

Here the small country is depending mainly on the external sources of innovation. The aim is to promote the transfer, adaptation, diffusion and development of technologies and with their help moving in the direction of the more advanced countries. With these technologies, the country is taking advantage of innovations developed in other countries in the framework of its budgetary, skill and other constraints.

The corresponding courses of actions would be:

A) To encourage the participation of national science in different international networks, to support the technology imports of national firms with information and advice. To motivate foreign firms to the constant technologic upgrading of their local operations.

B) To opt for highly cost effective appropriate technologies from sources which would promote constant and efficient upgrading the national technology base in the most important sectors. This involves locating the relevant information and setting up the necessary agencies or prompting the existing bodies to the diffusion of this information.

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[57] The emphasis of catch-up strategies may be for example on the learning process. Catch-up strategies involve the building of problem solving capabilities that enable the firm to improve its productivity, to imitate and to adapt product, process and organisational technologies already developed elsewhere to local conditions. It is during the catch up phase that firms "learn to learn" a skill which can later be applied to a process of continuous innovation. Keeping up requires a set of technological capabilities that lead to technological upgrading within the firm. Going beyond the production capabilities that underly competitiveness based on low wages and (or price) productivity ratios in the context of low-end market niches, firms must build investment and incremental change capabilities that enable them to modify and redesign products and processes, move into higher value added production and into new product generations. Continuous improvement in product quality is also critical here. These capabilities depend partly upon the development of in-house design, engineering, research and technology development and partly upon the ability to absorb and integrate knowledge acquired from elsewhere. Linkages to other actors thus complement the capabilities developed within the firm but cannot substitute for them. Getting ahead presupposes the capability to design and develop new products and processes. These may result from the combination of existing generic technologies or from R&D that pushes the frontiers of knowledge. In the past, the ability to sustain large-scale in-house R&D efforts conferred clear advantages upon a firm. Today, it is the size of the network to which firms belong that provides critical support to innovative activity at the technological frontier. (Lynn K. Mytelka i.m. p. 4.)

[58] There have been a specific policy model which developed in the former socialist countries. The Hungarian national paper in WP4 is dealing with this model in greater details, because it had a long-term influence on the R&D infrastructure, on the legal system and on the incentives and mentality of researchers. Corresponding to the postulates of central planning it was characterised by centralised decision-making. The priorities of applied research have been determined in the five year plans and the national innovation system was subordinated to the tasks of planning. The innovation system served to a large extent the copying of products and processes of the more advanced countries in the West. This process of "reversed engineering" required relatively large R&D infrastructure and secrecy. There has been of course a greater freedom and autonomy for basic research. There has been a rather intensive system of international co-operation between the members of the Soviet bloc. This co-operation was subordinated in the strategic areas to the security interests of the USSR. The participation of the research institutions, academies and universities in global co-operation was restricted by both sides of the military blocs. Still it represented the single largest area of East-West relations.

C) To develop the state of the art education which is able to move in the direction of the technology frontiers by taking full advantage of external achievements. To set up interactive information networks to promote the free flow of communication among all those who are interested in upgrading the quality of education.

D) This strategy requires an open policy that attracts transnational corporations. It is necessary to create incentives to speed up investment, especially FDI. This is wise because new technology is usually embodied in new equipment, but also in new work practices imported by foreign investors – especially TNCs.[59] That kind of policy emphasises the business infrastructure (e.g. logistics), availability of educated and flexible labour force, and financial and fiscal incentives offered to investors. Examples: Ireland, the Netherlands, Hungary.

Model 2.

In this model, the country depends mainly on national sources of innovations and the government is playing a fundamental role in the STI process. The aim is to improve the absorptive capacities of the economy by creating a national innovation system, including advanced education system, high level research community and research laboratories, lots of R&D funding and intermediary institutions to bridge the gap between research and industry. Such a system promotes creation of original innovations, but at the same time it also improves the capacity to adopt and develop new technologies created elsewhere. The system can be risky. It requires long term political commitment. Example: Finland.

The most important actions would be:

A) To develop appropriate institutions within the public administration to deal with long term STI projections and planning. To secure and increase the government budget for R&D (without trying to substitute private, contributions for public funds).

B) To apportion the state budgetary allocation on the basis of realistic feasible objectives, corresponding to the specific human and economic condition of the country, using foresight, benchmarking and cost benefit studies.

C) To offer fiscal incentives for improvements in STI effectiveness.

D) Instead of providing incentives only for greater enrolment in education, promote quality, efficiency and relevance in the educational system.

E) To promote international scientific co-operation in order to gain access to the main external sources of knowledge.

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[59] There are a multiplicity of ways in which TNCs can enhance the innovation potential of the host country: they can make an important contribution to its research system through R&D spillovers; they can incubate high-tech spin-off companies; they can act as conduits for the transfer of codified and non-codified technology through human resource mobility and intensive-interaction with the indigenous sector; and they can stimulate the creation of networks of suppliers of high value-added products, components and services to supply foreign-owned industry.

Model 3.

In this model, the market is playing a decisive role in the size, progress and patterns of STI. This is basically a laissez faire model. It is similar to the standard economics textbook model that the markets will take care of diffusion process. That, of course, may be the only alternative for a small country without sufficient resources to do anything. In this model there must be a powerful commitment on the part of the private firms in a number of exploratory areas of basic research.

The corresponding policy actions would be:

A) To promote the development of a competitive market, open to external and domestic resources, capital, information and knowledge flows. Special efforts should be made for the promotion of venture capital funds helping STI. There should be special incentives for industry to finance academic research.

B) To reinforce intellectual protection and ease the conditions in which patents are granted. For the sake of the smaller firms it is necessary to establish efficient permanent and/or ad hoc agencies to respond to the request for advisory assistance on issues related to STI.

C) To create bodies for information and for coordination which can help all the interested and involved firms or sectors.

D) To make special efforts to forestall major disturbances or misalignments in the system of STI and education, caused by international and national factors and competition. Institutions should be able and ready to correct the distortions of the market.

There can be different competitive and institutional practices, formal and informal arrangements in the framework of these models. All the three models require considerable policy support and their success depends on the continuous flow of new information about science, innovations and the market conditions. Model one and two put greater pressure on governments, model 3 requires greeter efforts from the firms. The successful implementation of all the three models depends on the regular dialogue between governments, business, the academic world and labour. All of the three models require the participation in the global flow of knowledge in one way or another.

The following analysis, which is based on the contributions of the national teams to WP4 is looking at the different national policy hybrids, particularly from the perspective of their effectiveness in achieving the goals, set by the relevant authorities and helping the countries in increasing their R&D capabilities and competitiveness.

The first is the Irish model. In Ireland the recent impressive transformation in the Irish economy in the 1993–2000 period, designated the Celtic Tiger, saw average annual GDP growth rates surge to 9 %, with growth in GDP per capita attaining similar levels. By the end of the decade Irish GNP per capita had caught up with the EU average.[60]

Many explanatory factors for the Celtic Tiger phenomenon have been advanced – the generous industrial incentives to FDI; the EU Structural Funds and CAP[61] transfers; the Single European Market; the social partnership arrangements with attendant pay restraints in return for tax cuts; the declining age dependency rate; the relatively highly educated labour force. Few commentators have cited STI as a significant factor in the story of the Celtic Tiger. The perception remains however that Irish enterprise comprises islands of high tech, knowledge-based FDI projects in a medium/low-tech-dominated economy. Many observers believe that the causality link between technological progress and economic growth in the case of Ireland should be drawn in the reverse direction i.e. Ireland's enhanced economic status is only now affording the government the resources to build up a NIS to international standards.

Up to the end of the 20th century now Ireland has been engaged in technological and economic "catch-up". The deficit in the country's technological capability, in its STI infrastructure and in the educational attainments of its workforce were all too apparent. There was no pressing imperative for comprehensive exante evaluation at the outset of every new program or initiative, because it was self-evident that virtually all projects being promoted were eminently worthy of support, even necessary, if Ireland was to address a serious "technology gap". In this climate the country's evaluation system focussed on assessing the impact of initiatives after they had been running for some time. At a more fundamental level, it is possible to argue that the particular choice of scientific domains that the country is planning to pursue intensely at this time, was arrived at through a political lobbying process rather than by an evaluation procedure appropriate to the expenditure involved.

The challenge for the future is to develop a more structured approach to the development of new STI program, including a formal appraisal procedure in advance of any decision on implementation.

This problem is highlighted by a recent recommendation from the Irish Science and Technology and Innovation Council (ICSTI) that Ireland should establish itself as a centre of excellence in selected niche areas of science, namely biotechnology and information and communications technologies. The Council recommended that 770 million Euros be allocated to this undertaking and the government has expeditiously agreed to implement this recommendation in its National Development Plan 2000–2006. His recommendation – and there will be others of comparable magnitude in a total Science, Technology and Innovation budget of 2,500 million Euros – was approved by the government in this particular manner, illustrates a major transformation within one decade in Irish Science and Technology Policy, a

[60] This delayed catch-up in the 1990s marked Ireland out from European countries who achieved their catch-up in the immediate decades following WWII (the "golden age").

[61] EU Common Agriculture Policy.

transformation that has implications, not just for the future of STI evaluation, but also for the country's system of governance.

This poses serious new challenges to the evaluation community in developing appropriate indicators of excellence, and associated evaluation methodologies. Analyses of publications and citations will no doubt be important tools, but additional supporting techniques are needed to assess the medium and long term impacts of such developments on the overall STI system, and on the economy and society in general.

The Finnish model has also a number of interesting characteristics, which may contain important conclusions for other small countries in promoting competitive national innovation system.[62]

The origins of modern Finnish science and technology policy date back to the 1960s and 1970s, when improving higher education and the research system was prioritised.[63] The prominence of education reflected broader goals of Finnish society in those days, especially the building a welfare state. While the importance of both science and technology for industrial development and economic growth had been acknowledged, it was only in the late 1970s and early 1980s when the S&T policies were embraced as immediate policy instruments for growth. The new focus was placed on creating genuine competitive advantages with improved quality and productivity, and on shifting production towards more high-tech and technology-intensive products.

During the last two decades, the Finnish economy has gone through a process of rapid structural change and technological catch-up. This transformation has diversified Finland into a modern economy with globally competitive high-technology production alongside the traditional paper, pulp and metal industries. At the same time, economic growth has become increasingly knowledge-based. These developments are widely perceived to be results of national science, technology and innovation (ST&I) policy stances, which have helped build a working National Innovation System (NIS).

The present Finnish National Innovation System (NIS) is based on the notion that it should aim at creating favourable and competitive conditions and environments for innovative firms. Any direct policy interventions should be limited to cases of clear market failure.

While the NIS concept is itself subject to criticism and continuous re-evaluation, in Finland it is has been a useful tool in developing STI policy. The NIS concept was adopted relatively early, in 1990, compared to many other OECD countries. The chosen approach essentially integrates the producers and users of knowledge and their interactions into one entity.

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[62] The information on the subject below is from the Finnish national paper in WP4.

[63] The Academy of Finland was founded back in 1948, but was reformed in 1969 to promote the development of research and research funding in universities. The Technical Research Centre of Finland (VTT) founded in 1942 was re-orientated to become a large-scale national technical research institute in 1972.

The major components of the Finnish innovation system consist of the national education system, research infrastructure, and a set of policy measures supporting product development and the growth of knowledge-intensive firms. New knowledge is produced by universities and polytechnics, research institutes and by knowledge-intensive firms. The foremost users of knowledge are not only producers of new technology, but also other firms, private citizens and public sector bodies responsible for societal development. In addition, the Finnish innovation system is permeated by wide-ranging international co-operation.

Rather than a hierarchical structure of organisations, the institutional structure of the NIS has been formulated with the aim of creating systems of intermediaries or funding institutions, incorporating mechanisms to generate network externalities.

A fundamental feature of the NIS is the widely shared belief that international knowledge spillovers and technology diffusion are conditional on a strong domestic knowledge-base and innovation system. According to this view the NIS and public STI policies should focus on building the domestic knowledge-base. During the 1990s, the international dimension of technology diffusion was strengthened with the awareness that most knowledge and technology was bound to be generated elsewhere. A distinguishing feature of the Finnish innovation system is, however, the extent of domestic innovation efforts compared to the technology diffusion oriented strategies commonly recommended to small countries.

Alongside the implementation of the NIS – approach, the cluster concept was merged with new industrial policy. Inspired by Michael Porter’s “The Competitive Advantage of Nations” (published in 1990), the Ministry of Trade and Industry introduced the concept as the cornerstone of its national industrial strategy. A number of programs exists that attempt to enhance the application of knowledge and new technologies within firms. The most extensive of these programs is the CLUSTER program, which is administrated by several ministries in co-operation. The cluster program was established to support the development of industrial clusters across the country, by means of allocating funds to their development. Cluster programs are extensive research and development entities that involve several sectors of industry. The aim of these clusters is to transfer and accumulate knowledge in chosen fields by promoting co-operation among various actors including both the producers and users of knowledge. They also aim to break boundaries between different sciences and fields and thus promote new innovations. Cluster programs are an outcome of the government's decision in 1996 to increase public R&D funding. Cluster programs can also be characterised as encouraging R&D co-operation by firms.

Although the effectiveness of several separate cluster programs have been somewhat disappointing, the concept has revealed new promising possibilities in combining regional and STI policies to gain mutual benefits, as well as learning opportunities on the role the public sector can play to strengthen networks and provide infrastructure for more effective STI policy.

The main top-level actor in the Finnish STI policy is the Science and Technology Policy Council (STPC). It is a governmental body which is responsible for the strategic development and co-ordination of Finnish science and technology policy as well as of the national innovation system as a whole. The Council is chaired by the Prime Minister. It assists and advises the government and ministries in questions relating to science and technology. The STPC participates in drafting STI legislation, but only in an advisory capacity on the most crucial legislative matters related to the organisation and prerequisites of research and the promotion and implementation of technology. The Council also issues statements on the allocation of public science and technology funds to the various ministries and on the allocation of these funds to the various relevant fields.

Thanks to the high profile of the Science and Technology Policy Council, various policies, such as industrial, education, environmental, regional, labour market, economic, fiscal, energy, health and welfare policies are more or less coordinated with STI policy. This coordination has lead to specific concerted efforts such as cluster programs, the Centre of Expertise Program, the education program of the IT workers, and new arrangements for venture capital. In other words, technology policy is the cornerstone of Finland's long-term growth strategy.

Few research results on the effectiveness of R&D subsidies in Finland are available. Though positive, the results are more suggestive and illustrative rather than detailed results on the returns on investment of various types of projects. A study by Maliranta (2000) suggests that public R&D policies and government interventions raise productivity through diffusion mechanisms that help firms adopt and exploit new technologies. Such industry specific spillovers are beneficial for both supported and non-supported firms. In another similar study, Maliranta (2002) suggests that R&D contributes to aggregate productivity growth through plant-level restructuring with a lag of 3–5 years. He also notes that competitive pressure is another important element of the creative destruction process. At the same time, however, Maliranta (2000) provides only weak, if any, evidence that public R&D support have direct positive impact on the productivity performance of the supported firms. This result seems to hold for privately financed R&D efforts as well. Lehto (2000) found that public R&D funding, be it in the form of loans or grants, does not crowd out privately funded R&D investments. According to him, an increase in public funding of R&D by one euro raised total R&D investment by an equal amount. Thus, on the aggregate, public support appears to translate into an equal increase in R&D investment.[64]

Another point worth making is that in the end, the return on public R&D investment is received mainly in the form of economic growth, generated by the innovations, in turn generated by the increased R&D levels public subsidies generated. Establishing this link is not clear cut. The best effort so far has been made by Lööf and Heshmati (2001)

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[64] Maliranta, M., 2000: Privately and publicly financed R&D as determinants of productivity – Evidence from Finnish Enterprises. In Asplund, R (ed.): Public R&D Funding, Technological Competitiveness, Productivity, and Job Creation, ETLA (Taloustieto), B 168, Helsinki. Maliranta, M., 2002: From R&D to Productivity Through Micro-Level Restructuring, ETLA Discussion Papers No 795, Helsinki. Lehto, Eero, 2000: Regional Impacts of R&D and Public R&D Funding. Labour Institute for Economic Research, Studies 79, Helsinki.

who found no significant relationship between innovation and productivity for the average manufacturing firm in Finland. Yet, at the same time, productivity in Finland ranks among the highest for OECD countries, and this is mainly due to rapid productivity growth in a few manufacturing industries.[65]

What is clear is that knowledge-based growth requires R&D to generate innovations to generate productivity gains to generate economic growth. So, even though the links between these factors may vary in intensity, innovations in Finland should provide some indication of where R&D produces high returns.

Industrial differences in innovative capabilities between traditional and rapidly progressing sectors are remarkable. These differences in sector innovativeness can simply emerge from differing phases in industrial strategies. Ormala (2001)[66] has pointed out that the forest industry procures over 70 % of the technologies it applies mainly from engineering, electronic and electrical industries. Industrial differences in innovative capabilities between traditional and rapidly progressing sectors are remarkable. These differences in sector innovativeness can simply emerge from differing phases in industrial strategies. At the other extreme, the telecommunications industry produces over 80 % of the technology it needs. That is, old traditional sectors tend to procure and imitate new process technologies when necessary, while firms in industries where technological progress is rapid compete with new innovations, and particularly with innovations new to the market. The crucial difference between the advanced use of new technology and innovation is not limited to differences in industrial maturity. Effective creation of new knowledge necessitates the effective absorption of existing knowledge. This pertains, for instance, to the use of ICT technology (OECD, 2000, Economic Survey). Such differences between the types of technological progress and needs for creating and absorbing knowledge, require selectivity in STI policies.

The paper of the Dutch team concluded that smallness has a profound influence on the Dutch economy and on the means to shape the National System of Innovation (NSI). Very important is the flexibility to cope with changes abroad and to keep the NSI efficient and flexible. Adjustments need to be implemented fast and effective, without much overhead in order to meet the Lisbon requirements. From the perspective of the comparative efficiency of the Dutch innovation system its evaluation, started in 2000 by the department of economic affairs and the consecutive implementation of its recommendations are particularly interesting for the WP4 of the KNOGG project. The evaluation in fact is a long-term project. The need was felt that the National System of Innovations should be improved and streamlined. Prior to 2000 there was no systematic and quantitative evaluation of STI-policy measures, or a clear picture how

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[65] Lööf, H. & Heshmati, A. & Asplund, R. & Nåås, S-O., 2001: Innovation and Performance in Manufacturing Industries: A comparison of the Nordic Countries, Stockholm School of Economics Working paper series in Economics and Finance No. 457.

[66] Ormala, 2001: KNOGG National Workshop held in Helsinki, Finland in April 2002.

to implement a framework for systematic evaluation of the National Innovation System.[67]

During the stream lining process a STI-policy model has been developed based on four "pillars". The first pillar is the tax credit system: WBSO. The second pillar aims at stimulating high-risk innovations (TOP), the third at stimulating R&D-co-operation among firms and between firms and S&T institutions (TS) and the fourth is aimed at enlarging the innovative capacity of SMEs hiring a recently graduated "knowledge carrier" (KO). In co-operation with Centre the Ministry of Economic affairs a new monitoring system with indicators has been developed. The intention is to evaluate every year and to publish the results and conclusions. The monitoring system consists of three levels.

The Dutch paper is looking at the R&D intensity of the KNOGG partners, and states that these small economies show lower R&D intensities than the big countries except Finland. The Netherlands and Ireland can be compared with each other. What these countries have in common is that their firm's R&D intensities are substantially lower than those of Finland. The difference between the Netherlands and Ireland is that the latter is increasing its relative position in the OECD while the Netherlands experience a deterioration of its position. This can be attributed to the strong economic growth of the Netherlands in the second half of the 1990s (denominator effect) but also because

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[67] The first step taken was to investigate evaluation systems abroad (i. e. outside the Netherlands). In 2001 a report was published with recommendations how to implement a framework to measure the relative effectiveness of technology policy instruments. The most important recommendations were that:

* Evaluation should be an integral part of the policy decision making process and not only provide information at the mid-term and at the end of a particular programme.
* Evaluation should be given ample (human), some central functions to improve expertise and organisational learning, and be closely linked to the strategic policy level in order to provide timely management information necessary to make choices between well functioning and less well functioning policy instruments.
* Management information necessary to make the right choices between different policy instruments consists of both ex-post as well prospective information.
* Data collection strategies at the outset of new programmes and monitoring and after a funded project are necessary in order to have some baseline data available to measure ex-post.
* Regarding the type of techniques: a combination of quantitative and qualitative methods should be used in order to make the best out of their strength and weaknesses.

After the publication of this report the Ministry of Economic affairs (EZ) started several rounds of expert meetings, resulting in a major update of M. E. E. T. (Meet 2001). The main conclusions are:

1) Consider the whole mix of STI-policy measures to increase the effectiveness of the National Innovation system.
2) To develop qualitative and quantitative information and statistical measures before implementing (new) policy measures (null measurement).
3) To develop a monitoring system.
4) More focus on exante evaluation for strategic purposes.

Already many of the recommendations have been implemented. The major step is to start with the consultation of all ministries involved in technology policy measures on a regular basis in order to get an overall view of the effectiveness of the NSI. The focus of the inter department consultation (IBO-consultation) is not only on technology but also on the knowledge infrastructure. At this point there is a strong link between technology policy measures targeted to the firm level and the whole system of higher education, research institutions.

Dutch firms spent less to R&D in real terms in the beginning of the 1990s. Hollanders and Verspagen (1999) have analysed why Dutch firm's R&D are lacking behind in comparison with other small countries. They distinguish the decline into a structural and an intrinsic effect. The structural effect is 45 % of the decline and describes the decline due to specialisation in sectors that are less R&D-intensive (examples: paper, oil refineries, plastic, shipbuilding). The intrinsic effect explains 55 % of the decline and describes the decrease due to less expenditure to R&D compared with firms abroad.

In Greece R&D-intensity is low but remained constant in the 1990s. R&D-intensities of the public sector (universities and research institutes) are substantially lower than those of private firms are (exceptions is Greece). There is – in contrast to R&D-intensities of private enterprises – no strong correlation between public R&D-intensities and the size of the country. The level for universities is in the Netherlands and Finland higher than in any of the big countries. Whereas Finland experiences a strong improvement in university R&D-intensities, the Netherlands show a strong deterioration as compared with the OECD-average. The KNOGG partners Ireland and Greece have experienced an improvement. The Dutch R&D-intensity of the research institutes can be compared with Finland, France and Germany and is higher than that of the UK and the USA. The relative position in the Netherlands remains constant in the 1990s.

In order to assess whether the R&D-infrastructure affects the R&D-output positively the Dutch paper analyses the output of the Dutch R&D-system and its impact on technological development. The total share of the Netherlands in global scientific output measured as the percentage of Dutch scientific publications in the total number of publications in the world is 2.3 in 1994–1998 and means that the Netherlands has the tenth place in the world (USA is number one). This relatively high percentage for a country of 16 million people can mainly be attributed to medical and life sciences, which is a typical specialisation of the Netherlands. In the 1990s a strong increase in the number of publications by Dutch scientists can be reported, 10 % on average. This increase can be attributed to the technical sciences and the gamma sciences, growing with 15.0 % respectively 15.7 %. The increase in the exact sciences is 9.2 %. The gamma sciences also show a high growth number, which can be attributed to the low starting position in the beginning of the 1990s and can be considered as an overtaking manoeuvre. These relatively good outcomes are the results of fundamental scientific research executed in the second half of the 1980s and the first half of the 1990s. As the budgets for Dutch university research are declining it is quite likely that these numbers in the period 2000–2005 will be substantially lower.

Investigating the impact of the Dutch R&D-infrastructure on economic growth of the Netherlands is, it is the paper analyses the patents of Dutch firms. Patents can be considered as an indicator of technical improvement of products or productions processes and hence contribute to the technological innovation capability and growth potential of a country.[68] Most patents come from the private sector. Universities and (semi-) public research institutes accounted for 3.7 % of the patents acquired in the European Patent Office (EPO). Part of university research is patented through the private sector because companies that funded the research often own these patents. In that case universities receive royalties.

The Netherlands performs very well relative to the average score. In both Europe and the USA the Netherlands performed more than average. In 1997–1998 the Dutch patent productivity score is 45 % above the European average in case of EPO and 40 % in case of USPTO. The relative high level have to be attributed to the fact that the Netherlands is a small economy, particularly in relation to the large numbers of R&D-intensive multinationals that are active in sectors in which many inventions are patented (like electronics, chemicals, pharmaceuticals, etc.). In Europe the Netherlands show the highest score. In the USA Dutch patents also have a high score but the decline combined with the increase of the Finnish patent productivity (mainly due to Nokia) is responsible for the fact that in 1997–1998 the Dutch move from to first to the second place and the Finns go from the second to the first position. Within the group of big countries Germany has a top position. This is consistent with the earlier conclusion that German universities already perform much applied research (see also Table 3). The low values of Ireland – combined with information that Ireland attracts much foreign direct invest-ment from the USA – suggest that foreign firms in Ireland often acquire Irish patents and that these prefer patenting their inventions in the USA (see also WP3).

The Netherlands acquires more patents than other European countries in the food production sector (Unilever, Sara Lee) and electronics (Philips). The food sector is considered as a low technology sector although parts of it can be considered high-tech. In high-technology sectors pharmaceuticals has a moderate patent activity while computers, office machines and airline construction even show a low patent activity.

The two “transition countries” Hungary and Slovenia share an important similarity. Their national STI policy model is still in the phase of transition in many respects. There is an evolution from a fundamentally state financed and implemented system to a mixed regime. In both countries, the transition to the market economy has been resulted in a major reduction of research and development expenditures and the diminishing number of researchers. The public research infrastructure the institutes and universities survived the transition but with financial and human losses and important changes in their functioning. Hungary still has excellent basic research institutions (mostly based on the Academy of Sciences) and a relatively strong position in a number of industries, which is supported by strong foreign direct investment. The collapse of the research infrastructure in industry was particularly conspicuous in Hungary Even excellent institutions have lost their funds and people. While all the governments emphasised the role of science and technology and more recently the

[68] Patents as an indicator of technological improvement have as a disadvantage that they probably underestimate the real technological improvement because inventions are not always patented for strategic economic reasons. Moreover, small firms do often not have the means to patent their inventions.

transition to a knowledge based economy and society, in practical terms this has not been among the top policy priorities.

Furthermore in Hungary the institutional reorganisations of the top government institutions dealing with STI have not been conducive from the point of view of science and technology. While the Academy of Sciences with its long traditions of basic research could survive and remained important, the traditional gaps between basic, applied and target research increased. The majority of industrial research institutes that were supposed to do mainly applied research and provide linkages between Hungarian science and industry, and facilitate the development of technology-based industrial clusters have been integrated with transnational corporations or ceased to exists. The universities of course could become far more important players in the innovation system than they currently are. At present however the universities are struggling with the conflicting demands of mass-education, and the requirements of becoming major actors in STI. One can agree with the views of a Hungarian STI policy expert, who stated:

> *"Yet attempts to devise and implement a coherent set of policies to strengthen the innovation system 'consistently' failed throughout the 1990s, regardless of the political stance of the actual government in office".*[69]

The paper of the Slovenian team in WP4 also arrived to conclusions similar to the Hungarian experiences concerning the declarations and government policies and the actual implementation:

> *"Vast array of different legal documents, instruments and mechanisms were introduced in Slovenia over the past decade, but with lack of commitment on the side of the government. In fact, one could say that every suggestion made by consultants or any instrument set up in EU countries regarding R&D and innovation policy has in one way or other been introduced in Slovenia, which might give an impression of the relatively high importance ascribed to innovation by policy makers. However, that is not the case. A wide gap exists between what was formally adopted and put into practice. But this has also increased the gap between the focus of public R&D and the corporate sectors' R&D, instead of contributing to pooling the existing resources to achieve optimal economic growth and development. The barriers and impediments to innovation are leading to the conclusion that a new understanding of innovation policy and the building up of innovative culture is needed to enable innovation-supported growth and economic development… To sum up, technology gap Slovenia is facing shows itself in relatively low share of business investments in R&D and technological development, in inefficient transfer of knowledge into products, services and processes, in low functional capabilities of employed and in insufficient partnership between institutions of knowledge and the economy. The level of innovative activity in Slovenian manufacturing is more or less*

[69] Attila Havas: Does innovation policy matter in a transition country? The case of Hungary. In the Journal of International Relations and Development. Vol. 5, No. 4. Ljubljana, 2002. p. 395.

stagnating, share of innovative firms in manu-facturing is fluctuating around the level of 30%. Differences between individual industries are significant, while for the services sector the figures are lower (at around 15%).”

The lack of innovation culture is also a more or less common problem. This is partly a consequence of the centrally planned system in which the forces of modern market competition were not present at all or they had not been strong enough. The improvements in international competitiveness in Hungary and the progress of high technology activities in manufacturing and services were the results mainly of those structural changes which were the consequences of FDI. The transnational corporations brought in new production technology as well as new products. This changed also the cost structure of innovations: the role of investments in new machinery and licence fees have increased.

The Slovenian paper offers the following conclusions for the weaknesses of the country in STI:

“As a conclusion, the main weaknesses in the STI area can be summarised as follows: a) low innovativeness and efficiency of resources used for R&D, b) weak systemic organisation, c) targeted generation and development of new knowledge is not focused enough. These weaknesses contribute to lower contribution of science and research sphere to the development of innovation activities in the society, which impedes improvement in the competitiveness of the Slovenian economy.”

From the above comparative discussion, it is evident, that no general policy prescription can be made which will be applicable in all countries, even than, when “smallness” as a common denominator may be a source of certain similarities. In the KNOGG countries none of the three models seem to exist in its “clear” form. The empirical analysis particularly in WP2 proved that these countries developed different policy “hybrids” These hybrids may be containing important components of one or an other model.

Nonetheless, there are some general criteria relevant for all the countries. Successful national innovation systems must be built on a strong commitment of governments and business to develop the national research base, coupled with the capability in R&D orientation towards external markets. These policies and commitments must based on a national consensus concerning the main long term goals. The institutional system of national innovations must have flexible structures and methods, which ensure that multiple channels and options are kept open for the creation, diffusion, transfer and application of technology. The policies must have a supportive information and financial infrastructure. The favourable broader environment for the development and functioning of the national innovation system should enshrine competition policies, an appropriate fiscal policy, human development policy, regulations codes and standards, which take into account the interests of the society. Measures, which encourage and facilitate the participation in international networks of firms, universities, research institutes and researchers must be also parts of these policies. It is a very important question, which requires further research, which policy models or hybrids will be “optimal” in a European Research Area?

4.2 The usefulness and limits of comparative indicators for “benchmarking” in evaluation and formulation of STI policies in the KNOGG countries

Rational decisions by the governments or other actors in the STI system are impossible without a well developed information base. For almost half a century efforts by different international organisations and national statistical offices have been made to develop indicators on STI which facilitate the systematic measurement and international comparisons of inputs and outcomes. A great number of indicators are used today around the world to measure different dimensions of science technology and innovations. There is a fast progress toward elaborating and accepting standard methodologies that aim at simultaneously establishing mutually compatible national and international systems of science and technology statistics and indicators. STI activities are diversified and are taking place in different settings and sectors even in the small countries. The innovation process is influenced by different domestic and international factors. Decisions on the different factors are also numerous. Some of these decisions are based on the subjective judgements of individuals who are representing the “wisdom” of different institutions. Other decisions may be based on anecdotal information or on the international “demonstration effect”. They may be the outcome of well informed experts, or other individuals, representing different interests and claims. This type of information and knowledge is widely used in the often mentioned and increasingly popular foresight exercise, The role of factual information based on measurements and objective statistical surveys, on the status of the STI system and on its trends is growing also in STI decision-making. It may serve for measuring effectiveness, for checking anecdotal assertions, for building models which describe the operation of the different components of the STI system under various assumptions.

The statistical indicators are playing multiple roles. One of them is the *evaluation of the results of national STI efforts on different levels*.

The importance of evaluation of both the inputs and the results of STI received particular attention also in some of the KNOGG participants. The Irish national report to WP4 for example stressed particularly firmly its importance.

It was referring to a recent ICSTI Task Force Report[70] which emphasised that, while the State’s expansion of STI funding was beginning to approach international norms, Ireland still lagged behind international best practice in terms of evaluating the benefits of such funding provision.

[70] ICSTI (2002), Measuring and Evaluating Research, http://www. forfas. ie/icsti/statements/stiresearch02/020827_icsti_measuring_and_evaluating_research.pdf.

The report noted that the re-orientation of Irish public policy towards science, technology and innovation has not yet been reflected in an increased and generally embedded capacity to evaluate such policy initiatives, particularly in relation to exante evaluation, and to appreciate “newer” indicators of the “knowledge-based society”.

The Report declared:

> *“The development of the National Innovation System is Ireland’s key to sustaining competitiveness in the evolving knowledge based economy. A system that effectively evaluates or measures the outcomes from the research effort is essential if the return on investment is to be optimised.”*

The report highlighted the role of indicators and evaluation techniques in addressing the concerns of a number of audiences: for policy-makers in meeting the requirement of public accountability in the disbursement of public funds, for the scientific and technological community in demonstrating the economic and social benefits of publicly supported scientific endeavour, for both policy-makers and researchers to enable learning about policy design and delivery, and to facilitate the continued development of the innovation system.

The report found a dearth of expertise in terms of evaluating the outcomes of expenditure on STI within Irish public sector bodies. It recommended that all public policy agencies should have the expertise to evaluate STI expenditures, given that research is now central to Ireland’s economic and social development. The report looked at international best practices for the evaluation of STI funding and indicated that Irish policy-makers should have access to these skills.

Specific recommendations in the report include:

* That the choice of indicators and evaluation techniques be generally governed by an appreciation of the underlying complexities and uncertainties of scientific research and technological development, the resource costs of such exercises, and the impacts they may have on the incentives of researchers.
* The production of indicators and the conduct of evaluative exercises should take full advantage of the range of techniques available, or under development internationally i.e. a “portfolio approach” is recommended rather than reliance on unduly simplistic, “one-shot” summary measures.
* The continued development and use of such techniques by specialists agencies such as Forfás, the HEA, and SFI and evaluation units involved in STI activities.
* The dissemination of information on, and the results of, such techniques in the wider policy community, through publications and conferences/seminars on these themes, so that expertise in indicators and evaluation techniques for STI policy be more widely embedded in public policy agencies in Ireland, to more fully reflect the cen-trality of this domain of policy to economic and social development.
* Consultation with the scientific and technological communities as to the evaluation approaches adopted or under consideration.

* The much wider use by funding sources (typically government departments) of a formal ex-ante evaluation prior to approving the introduction of any new or revised STI initiatives.

The report noted that evaluation of the outcomes of STI activity was complex, given the uncertainty of scientific research. It highlighted the dangers of simplistic evaluation approaches, and recommended the provision of a specific allocation for the costs of proper monitoring and evaluation within the overall budget for each STI support program.

The other important role of indicators is to promote international comparisons. Meaningful international comparisons are possible only, when they the countries use reliable and standardised statistical base. In the KNOGG project we used the available data from Eurostat, OECD and more recently the KAM developed by the World Bank. KAM is based probably the most thorough analysis of existing capacities and conditions for organising reliable measurement. Most of the statistical systems follow the sequential input-process-output-impact line. Traditional S&T input indicators are based on the measurement of the expenditure incurred in and the personnel devoted to R&D activities or to STI activities.

One of the areas, where factual information is particularly important is the benchmarking exercise which has become a popular instrument also for STI decision-makers on different levels of activities and it is also important for helping the implementation of the Lisbon strategy.[71] The idea behind benchmarking is simple: find out what the best performers are doing and catch up, fast. It is a valuable idea for those who are exposed to international competition and are behind the standards of the best performers.

In an interesting paper, on "Benchmarking policies and institutions in the KNOGG countries using KAM and alternative tools", written by Torsten Santavirta, of VATT it has been stated that benchmarking the impact of science, technology and innovation policy on competitiveness and economic growth it is important to take into

[71] The Lisbon Council 2000 set the goal to make Europe the most competitive and dynamic knowledge-based economy in the world by 2010. This goal included plans of increasing the capability of sustainable economic growth, creating 20 million additional jobs and thus increasing the employment rate to 70 % (an increase of almost 10 % from the European level in 2000) and increasing the social cohesion. To achieve these far reaching objectives, the European Union member countries adopted a Lisbon Strategy, combining short-term political initiatives and medium- and long-term economic reforms. It is evident that measures to achieve the goal are now implemented. In terms of research and development, an important issue has been how to develop an unified research area of Europe. A major step in this direction is the European Research Area program (ERA) which has provided a framework for research policy in Europe since 2000. Strengthening the interaction between researchers in the member countries will help to improve the overall efficiency of European research efforts. It will be difficult to implement such a large scale strategy, in an area with economic, political as well as cultural diversity, to understand the national policies and the country specific impediments for growth. The Open Method of Co-ordination is chosen as a method to implement the strategy. It includes benchmarking based on quantitative and qualitative indicators, the setting of specific timetables and the translation of European guidelines into national and regional policies. In the open method practice, benchmarking is an important means of evaluating the performance of national policies, especially science, technology and innovation policies. It increases the transparency of national practises and allows for comparing the success of national policies.

consideration a wide range of factors and processes that affect the structure and performance of the economy. Benchmarks of the performance of these STI policies which have an eventual impact on competitiveness and employment are thus highly desirable as inputs to improved policy making. Benchmarks help to develop standards against which performance can be assessed. In STI policy making benchmarking is an important way of assessing the national R&D policies and performance, in order to improve policy-making. The benchmarking exercises provide information in the form of indicators that capture the changing relationship between science, innovation and the economy. They are thus crucial so that policy makers may evaluate how their performance compared to that of other countries, make informed decisions and set priorities as to where greater efforts may be needed, and identify the challenges posed by the knowledge-based economy.

From among the different sets of indicators which are used for benchmarking research policies and STI strategies, in the framework of the KNOGG countries the European Innovation Scoreboard (EIS) is the most relevant.[72] Its 17 quantitative indicators focus on high-tech innovation and are divided into four groups: Human resources, creation of new knowledge, the transmission and application of knowledge and the innovation finance, output and markets. They resemble to the indicators used by OECD (Science, Technology and Industry Scoreboard), but it is much more detailed. The OECD STI-Scoreboard compiles over 160 indicators. The World Bank Institute's (WBI) program "Knowledge for Development" uses a benchmarking tool called knowledge assessment methodology (KAM) which consists of a set of 69 structural and qualitative variables that benchmark the economy in respect to its competitors or the countries. KAM helps to identify the problems and opportunities that a country faces, and where it may need to focus policy attention or future investment.

For national policymakers in the KNOGG countries it is important to benchmark their countries in comparison with the other smaller countries in Europe and relate them to the Western European or EU averages.

In June 2000, the Research Ministers instructed the Commission and the Member States to benchmark national STI policies in the field of human resources, including the attractiveness of scientific careers, public and private investments in research and technological development, scientific and technological productivity and the impact of research on economic competitiveness and employment. It has been agreed to use a set of 20 macro-level indicators. This use of benchmarking is serving both for comparative analysis and for supporting policy decisions. We quote from an important EU document, for illustrating the role of benchmarking in analysis. The document stated:

> *"The innovation performance of Member States, Candidate Countries and certain other European States, and of the Union as a whole, is measured by the Commission's European innovation scoreboard. It demonstrates the*

[72] See: 2002 European Innovation Scoreboard: Member States and Associate Countries. European Commission. Enterprise Directorate General and IPTS. Enlargement Futures Project: Expert Panel on Technology, Knowledge and Learning. Final Report. Nov. 2001.

> *weaknesses in the Union's position relative to the United States and Japan. There are nonetheless some encouraging features of Europe's innovation profile. Both the 2001 and 2002 scoreboards 15,16 show that for many innovation indicators the leading countries of the Union are ahead of the United States and Japan 17. Both scoreboards also demonstrate the wide variety of innovation performance in the Union, and possible diverging trends between Member States for some innovation indicators. These considerations highlight the potential for exchange of good practice… Many of these focus on completing the process of structural reforms of labour, capital, goods and service markets and improving the regulatory climate for business… Enlargement will significantly change the Union's innovation profile. The available evidence points to strong disparities in the innovation frameworks and performance of Candidate Countries compared to Member States."*[73]

The scoring on the basis of the KAM method gives very different results for the KNOGG countries. According to some of the indicators, like the average annual GDP growth the KNOGG countries are divided into two groups, the ones who get top scores and the ones with a very mediocre growth rate. Ireland, Slovenia and Hungary get top scores (10.00, 8.62, 7.70 respectively) while Finland and the Netherlands disappoint with 2.86 and 3.33 respectively. Using Western Europe as the reference group, the KNOGG countries show widely different scores on the economic regime indicators. Finland seem to have a fairly restrictive trade policy while Ireland is number one in Europe regarding openness of trade with full score 10. All KNOGG countries except for Ireland have high scores on the IPR indicator that measure how well intellectual property rights are protected. Finland is number one in regulation of financial institutions while Ireland and Slovenia get low values on this indicator. The performance of the innovation system can be evaluated using indicators such as Technology Assessment Index, number of patent applications granted, the private sector spending on R&D, the total expenditure on R&D, foreign direct investments, research collaboration between companies and universities and availability of venture capital. When Western Europe is used as reference group the KNOGG countries do well in comparison to the rest of Europe showing number one scores on all the indicators. The Finnish innovation system is ranked number one (10) on the technology assessment index and on the indicator that measures the degree of collaboration between companies and universities. Hungary's innovation system does best on the indicators in comparison to the other KNOGG countries. It places number one (10) in private sector spending on R&D, research collaboration between companies and universities (shared number one with Finland) and availability of venture capital. Also Slovenia has three number one rankings, private sector spending on R&D, total expenditures on R&D and patent applications granted. Ireland performs relatively poorly on all indicators regarding specifically innovation except for foreign direct investments, on which it is clearly above the EU average.

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[73] Innovation policy: updating the Union's approach in the context of the Lisbon strategy Communication from the Commission to the Council, the European Parliament, the European Economic and Social Committee and the Committee of the Regions COM(2003) 112 final.

The performance of the innovation system is depending also on the general educational standards within the system. A well-educated population has a higher capability of taking advantage of technological advances than a poorly skilled population. Broad indicators of social and human capital are: percentage of GDP spent on education, percentage of working population with tertiary education and the degree of participation in life-long learning.

Finland is the country with the highest percentage (32.4) of the population with tertiary education. The EU average is 21.2% and Greece is considerably much lower with only 16.9% of the population having a third-level degree.

Among the KNOGG countries Finland has the largest public spending on education while Ireland has very low values on this indicator. The participation in life-long learning is an important indicator of human resources. The Council of Europe defines life-long learning as: “all purposeful learning activity, whether formal or informal, undertaken on an ongoing basis with the aim of improving knowledge, skills and competence”. The current interest and support for life long learning is based on the belief that continuous learning is required to address several economic, technological and demographic changes in modern economies. On this indicator Finland and Netherlands find themselves remarkably above the EU average while Ireland is under the EU average.

Greece has not been included into the KAM statistics. An other source, the DG Enterprise’s Innovation Scoreboard 2001 indicated a poor Greek performance. The Greek chart indicated an average annual public expenditure on industry-oriented support measures of 0.2 % of GDP. The WEF Global Competitiveness Report 2001 ranked Greece 36 out of 75 countries by its Growth Competitiveness index, the lowest of the KNOGG member countries. *Greece lacks applied research organisations of a stature capable of bridging the divide with basic research and spawning new sectors in the Greek economy*. Greece has a number of established public applied-research institutes but they operate in low-tech sectors such us, metallurgy, textiles, ceramics, marine, and agriculture. *The culture gap between SMEs and the Higher Education sector places an unfair onus on academics to be proactive in HE-Industry liaison*. This is very much the case in Greece where universities are still firmly set in the traditional mode. The recent transfiguration of the Technical Educational Institutions into Higher Education Institutes suggests that they, too, may be distancing themselves from the grind of industry. *Firms in Greece need help in enhancing their absorptive capacity* – the “initiative” ability to adopt and modify already commercialised external technology (TT) and the more creative ability to commercialise external research results from HE and public research institutions. Greece is the EU country with the lowest part of population participating in life-long learning.

The scoreboards and the benchmarking exercise must be dealt with of course with due qualifications when they are serving policy formation.[74] The greatest danger is when

[74] In 2001 at a conference organised by the Directorate general for Research of the European Commission, one of the keynote speakers B. A. Lundvall stated that there are two types of benchmarkings: naive and intelligent.

policy makers want to copy other, more successful cases mechanistically. There is also a psychological factor involved. By establishing the best standards all others can be judged or feel as a failure. Different environments may require different solutions and combinations of factors. It is also a major problem, if too many factors are included and used in the comparisons. One should keep in mind also the famous Pareto principle that in most cases only 20 per cent of the factors drive 80 per cent of the performance. It is necessary to understand better the relative importance of the different factors in STI benchmarking. The time frame and the longer term trends must be also taken into account, with equal emphasis on input, output and process indicators. Benchmarking and the identification of best practices may provide at the same time useful information for managers or decision makers in governments, and also to international organisations, but it should be only one of the starting point of analysis which is needed for setting priorities and goals in national policies. It may be of course an important tool also for the academic research.

Foresight is an other important multipurpose and increasingly popular instrument for policy makers. Its goals are of course not new. Governments, corporations, international organisations and academic groups used science and technology forecasting for the support of their long-term goals. Foresight studies are aimed at the development of a common vision for the society, they identify future technologies and technological changes, they intend to guide national technology policies and offer "intelligence" for the different firms and institutions. They combine science vision, business vision and social vision on science and technology. The concrete goals and choices are of course influenced by the cultural, economic and institutional characteristics of the participants of the foresight exercise. According to the Report of the Irish team in KNOGG, the basic aim of Foresight exercise in Ireland for example is to assist the repositioning of industry higher up the economic value chain. This will be done by supporting selected technologies which are key to long term sectoral and national development.

From among the KNOGG countries, the foresight exercise has been used most extensively in Ireland. The country may serve as a "benchmark" for other KNOGG countries in this context. The Irish report to WP4 stated:

> *"Foresight investment must signal internationally that Ireland is becoming a high quality research location, and a credible option for mobile research-based foreign investment. To meet these objectives, and taking account of the stated Foresight position on sustainability as understood by the universities, the following principles are proposed to guide Foresight investment policies in achieving its objectives.*

Naive benchmarking is characterised by superficial comparisons, which ban be easily misplaced and, if they are left to guide policy, can be dangerous and have socially damaging implications. In contrast, intelligent benchmarking recognises the complexity of political, economic and social phenomena as well as the limitations of its heuristic tools. The conclusions of the conference stetted that benchmarking is not comparative research, it should however acknowledge the constraints of its assump-tions. (N. Castrinos, DG RTD European Commission: The Contribution of socio-economic research to the benchmarking of RTD policies in Europe. Conference Document.)

* *Quality – The standards of Foresight funded activity must be unequivocally world class, as determined by competitive, peer-based assessment processes.*
* *Critical Mass – The scale of investments must match international standards in the sectors supported for a critical mass of personnel and facilities.*
* *Visibility – Projects must have the potential to offer high international visibility and provide the opportunity for Foresight "branding", for use in international marketing and promotion.*
* *Flexibility – Arrangements must be flexible and be capable of being changed or shut down, without long term financing obligations for government.*
* *Relevance – Longer term, investments should offer the potential for commercial opportunities, for spin-offs, new technology-based start-ups, technology transfer and the attraction of knowledge based foreign investment.*
* *Transparency – Proposals must offer fully transparency management, accounting, monitoring and reporting processes.*
* *Partnership – As a general consideration, there should be opportunities for co-operative partnership arrangements, engaging, where appropriate, government, universities and industry."*

The participants made use of "scenarios", or pictures of where future markets and technological opportunities might lie. Scenario-planning was used in Technology Foresight exercises to test the strategies being proposed for each sector for their relative robustness in the face of any combination of future uncertainties. This approach ensured that robust and flexible strategic choices would be recommended for Ireland's technological development over the next 10 to 15 years. The use of scenario-building facilitated large companies, smaller enterprises, the public sector partners and researchers to break out of the constraints of thinking about the future based only on current experience and trends.

In 1999, in its overview report on the Technology Foresight exercise, ICSTI outlined a vision for Ireland in 2015[75] as a Knowledge Society where:

* *a significant proportion of industry has become technology-based, and robust in the face of international market developments,*
* *an export trade in R&D and technology services in certain niches has developed,*
* *Ireland has developed a substantial number of large and small indigenous technology companies that are internationally competitive,*

[75] ICSTI (1999), Technology Foresight Ireland: An ICSTI Overview.

* *Ireland has become a sought-after location for advanced technology firms to perform R&D, interact with the Irish STI system and produce and export innovative goods and services,*
* *industry, universities, colleges and State institutes constitute a vibrant research partnership, particularly in the key enabling technologies,*
* *access to the best international knowledge has become widespread, as has collaboration with the research base in Europe and the US, especially through the diaspora,*
* *the Irish labour market can now meet the high tech expertise needs of the productive sectors,*
* *Irish researchers have become world renowned in niche technological areas,*
* *attractive employment opportunities now exist for researchers in science and engineering disciplines, and leading Irish researchers have been encouraged to return,*
* *venture capital has become more widely available to technological areas,*
* *Ireland's infrastructure, particularly in telecommunications and transport, has come into line with the needs of an advanced technology community,*
* *higher standards of living are being enjoyed by ever increasing numbers of people.*

Other KNOGG countries also established foresight groups. The use of their results depended to a great extend on the absorptive capacity of the decision making process. The Hungarian government run a foresight project also, in order to provide the necessary analytical background for future innovation policy. The project was called Technology Foresight Program (TEP). It summarised fairly well the general knowledge about successful catch-up policies, the changing nature of socio-economic parameters in the knowledge-based economy, and the new requirements with which education, research and development and government agencies were to be addressed. TEP also developed three possible scenarios for technological development of Hungary, in case there was an active or passive strategy, and in case there will be fundamental changes in world economy and in world-wide co-operation links. The option of adapting a passive policy under circumstances of rapidly changing environment was not regarded as plausible.

TEP conclusion was that the country should enter a development path that tries to play an active role in shaping its role and links to the changing world economic environment. In fact, many of the already decided documents, and measures may play a role in shaping this development policy. The problem is as it was the case also earlier, that little impact was produced. The documents looked nice, but the established judicial and even financial frames remained unattended, the projects made little impact. A number of institutions were set up in line with the TEP guidelines. New policy focuses were set, in certain areas even some money was allocated, but there was not enough determination by the authorities to run the institutions efficiently. Allocation system of resources remained arbitrary, inefficient and sometimes counterselective. By and large it is still the unchanged bureaucratic machinery that hinders quick and effective allocation of resources. We recall here the fate of the former quasi ministry OMFB that was disbanded and amalgamated into the Ministry of Education when it threatened the old status quo.[76]

[76] See: Havas, Attila: Evolving Foresight in a Small Country in Transition: The Design, Use and relevance of Foresight Methods in Hungary. Journal of Forecasting, (forthcoming).

5. Public perceptions concerning R&D and innovations. The role of the public in the development of science, technology and innovations in the KNOGG countries and beyond

In this chapter we are focusing on the relationship between science and technology and the society from the perspectives of progress toward a knowledge based society. In the KNOGG project the social aspects of STI have not been dealt with in specific terms. Nevertheless they have been in the background of those processes which formed or influenced national policies. In the context of policies there are several problems which are directly related to the public's perception of science and technology. The influence of science and innovations on the society is probably the most widely discussed important issue. There are of course other questions. Why for example certain societies can innovate more easily and absorb innovations faster than others? The motivations to innovate depends to a great extent on the direct and indirect influence of science and technology on the different layers of society, but also on the general intelligence and attitude of the population. This influences also the diffusion and role of knowledge.

From the perspective of the KNOGG project, specific problems related to the society in smaller countries are also an important dimension of the questions. It is well known that in small countries resources in absolute terms are more limited, as are opportunities, because of the scale of activities. While the importance of knowledge is universally acclaimed, the intrinsic economic value and overall contribution to socio-economic progress may be quite specific. The chapter is looking at these and other issues in a broader perspective.

5.1 The impact of science and technology on society and the public's perception of science and technology

In the eyes of many people, science took the place of ultimate authority instead of (or besides) religion. Some started to think that science is omnipotent, anything can be solved by the means of it. It is important to note all these, because human society is still part of and determined by this process. During the 20th century science and technology became increasingly integrated into the institutionalised policy making process. The process has become more contradictory after the 2nd World War Science and technology have a growing and more complex impact on human society, including the environment. The simultaneous of the positive and negative influence of science has created a rather ambiguous attitude toward science and innovations in the society.

It was already clear by the 1960s, that in some cases science and technology endangers the environment around us and even the very life of human beings through nuclear weapons and nuclear energy. New medicines come with a danger of misuse and side-effects of them. Concerns about further physical, mental and ethical aspects of life have also come to the foreground. The IT-revolution has accelerated the flow of information at and between workplaces. This, together with other causes, increases stress, in most cases without a decrease in actual working hours. Personal privacy is challenged by some aspects of information and communication technologies (ICT). The possible hazardous impact of electronic devices on human health has come under discussion (monitors, air-conditioners, mobile phones, etc.). Genetically modified organisms in the food industry meet criticism. Cloning (especially human-related) has emerged as an ethical issue. The psychological and social impact of electronic and mobile communication can be captured by "internet-dependency", physical isolation, a re-shaping of language and communication and the birth of virtual communities. Television, video-games are criticised for dominating free time and endangering literacy and numerical skills of the new generations. The strongly increasing amount of information emitted due to the ICT-revolution makes the selection and digestion of them more and more difficult. The inequalities in access to ICT (the "digital divide") are also a growing concern.

It is important to note that science and technology as such is not responsible for most of these problems. As Brenner (1998) puts it

> *"There are many problems that science and technology by themselves, are unable to solve given the economic structure of that we live in. (...) I wish I could say that we will still have a planet to live on ... this does not depend on science alone but on economic forces and political wills, something that scientists do not control."*

In one of its document, the EU stresses that "*a distinction also needs to be made between hazards due to new scientific and technological developments and hazards due to industrial practices or criminal negligence*." (EU, 2000, p. 11.) Therefore what really matters is defining priorities and after having some results, what to implement of, how to implement, and in what priority to implement scientific and technological achievements.

In the smaller countries, where the society is less exposed to the "mission oriented" R&D policies and the people are less aware of the mechanisms that connect sci-ence with everyday life the public may be even more sensitive to the negative aspects of STI. On the surface, things can appear as the failure of scientific or technological achievements. Therefore opinions range from putting the blame solely on science and technology to declaring the victory of science and technology.

There are of course general sources of anti-science attitudes, which are not related to the size of the countries. Anti-science sentiments and arguments can have different origins. They can come from real experiences: globally known incidents, like Chernobyl, Challenger and Bhopal and locally known cases of environmental distraction. Another reason is originating from justified, unjustified or debated fears of the impact of sciences and technology on our life. A fiercely debated issue is genetically modified organisms (GMO) that are becoming part of human diet. Somebody opposing GMO is not necessarily against science, but if this fear is generalised into the claim that any biological or chemical treatment of plants severely threatens our life, the fear becomes an anti-science statement.

Anti-science sentiments can be based on not only practical fears, but ideas as well. Religious ideas can be an obvious reason. New religions founded in the 20th century do not fundamentally differ when it comes to anti-science sentiments. There are other non-religious organisations that are based on metaphysical beliefs. However, none of these non-materialist ideas do actually lead to anti-science view. Much depend on the interpretation of religious (an other) teachings, the role it has in an individual's life. After all, there are many scientists who are religious themselves. Also there is a spread of a range of superstitions and pseudo-scientific arguments and methods (astrology, "tele-curing", remote-viewing, "paranormal" activities, etc.) that are in a more direct relationship with today's anti-science sentiments.

There is also a sense of mysticism and stereotypical thinking about science. For many people the scientist is somebody dealing with things that hopelessly can not be understood, somebody severely single-minded, isolated from the realities of the day, possibly even anti-social or irresponsible for the outside world. These perceptions can also contribute to negative attitudes to science and technology.

There are cases when scientists themselves (unconsciously or deliberately) publicise results that are regarded scientific, it is proved later that they are not. These are clear cases when science is abused through attempts to negate, misapply, distort or falsify research. Heller (1986, pp. 123-141.) gives some concrete examples for this in the fields of social and biological sciences. Directly or indirectly these kinds of abuses can serve as a ground for anti-science or pseudo-scientific sentiments.

For the majority of the public and the decision makers it is often comfortable not to seek explanations in the complex set of ties between political/economic power and science, namely the way the economy and society is organised. Instead of this, attacking or defending science (or technology) is easier. But the way to counter simplifications and false beliefs is to make the public understand the economic and social background and the results of scientific research and technological development. This falls into the responsibility of scientific researchers, institutions and supporting organisations, policy making bodies. Scientists cannot distance themselves from political or ethical issues any more. As Nobel-prize laureate John Ziman put it: "*As their products become more tightly woven into the social fabric, scientists are having to perform new roles in which ethical considerations can no longer be swept aside*." (Ziman, 1998) In the same series of articles Augustine (1998)[77] argues that in the past scientists and engineers were measured by nature, today often judged by humans.

Having in mind all the positive impact and dangers of science and technology and the limits set by private and public interests a balance has to be found between the

[77] The Science magazine (US) has celebrated the 150th anniversary of the foundation of the American Association for the Advancement of Science (AAAS) by a series of articles during 1998. These are two of them.

principle of freedom to research and the responsibility of using scientific and technological achievements. But in another dimension, the limitations by private and public interests can be shifted as well.

In spite of the views related to the negative impact of STI science does still possess strong authority in the eye of the public. At least stronger credibility than institutions that claim to represent "the people", "the majority". According to an Eurobarometer Survey conducted in May–June 2001 in the fifteen EU-member states,

> *"80% of Europeans believe that science will one day conquer diseases such as cancer or AIDS, and scientists enjoy a high level of public confidence, to the extent that 72% of the respon-dents said they would like politicians more frequently to use expert advice in making their choices (...) the same survey also shows that Europe's citizens do not always have a very positive perception of science and technology, and that science is remote for some sections of the population." (EU, 2001, p. 4.)*

Scientists themselves are sometimes accused of spreading anti-scientific or pseudo-scientific views. Science is partly about entering new areas of the unknown. Thus it can seem that the borderline between science and non-science is not clear. A distinction has to be made here. There can be different schools and even philosophies in the most exact sciences as well. A different, new, unusual result is sometimes attacked by other scientists claiming that it is not scientific or pseudo-scientific. A debate, a scientific justification is needed in these cases. To solve the controversy, the method and basic data used for achieving new results should be checked.

5.2 The specific case of Hungary

We have to point out some specific characteristics of Hungary, that can have validity for other transition countries. With the political and economic changes of 1989 and after, earlier ideas and lifestyles were challenged. Most of the people had to find their (partly or wholly) new identity and attitudes to changing circumstances. The ruling ideas emphasised materialism, a rationalistic view of the world. As the backlash came, many people turned away from this kind of ideas generally heading towards religious, superstitious or pseudo-scientific ideas. Higher unemployment and insecurity pushed people to supposedly safe havens of transcendence. These together with the earlier mentioned global factors contributed to form a basis for anti-scientific or pseudo-scientific sentiments.

A poll of 1000 Hungarians adds to the above mentioned in terms of the perception of science showing that anti-science sentiments are far from being a general and dominating phenomenon. (Tamás, 2000) As for personal side of the story, 15 % of the respondents stated that they know scientist(s) in their environment. This high ratio shows that some people can believe that a person is a scientist. More than half of the polled thinks that researchers and scientists lead a different way of life compared to others. 80 % said that they would support their children to become a scientist, a much higher ratio compared to poll results of the 1980s. The positive acknowledgement of science can mix with anti-science sentiments in the same person's mind. While more than 80 % mentions the improvement of living standards and the nation's prosperity, 57 % states that people often lose control of science and technology, 23 % saying that researchers, through their knowledge, pose a danger to society. More concretely 76–80 % thinks that computers and automatization have improved the quality of life. "Laser-rays" are the second most positively perceived technology, while those areas with a supposedly smaller significance for the ordinary people (atomic energy, genetics, space technology) are less frequently mentioned.

As for actual scientific knowledge, the public seems to be more informed about geology than physics (especially radioactivity). It is a striking result of the poll that only 46.7 % thinks that human fate and characteristics do not depend on the constellation of stars at their birth.

Hungarians have a positive general evaluation of the abilities of Hungarian scientists putting them well over the average in international comparison. (Hungarian scientists living abroad are counted by the majority as part of domestic science.) The US and Japan are regarded as the leaders in science and technology. The respect for Germany is bigger than for the United Kingdom.

As for future (next 25 years') expected achievements, curing cancer, forecasting earthquakes are the most common (71–72 %). New modes of generating energy, a reliable control of the economy was mentioned by 41–55 % of respondents, creating human settlements on other planets got only 24 %. To give a comparison regarding the state's role, 87–90 % said that health, economic growth, environmental protection has to be set as priority, with 84 % of the opinion that science has to be supported by the government. Art and ethnic minorities got less than 50 %.

According to a survey on internet and mobile communication in Hungary in 2002, 70 % of the respondents stated that the new communication technologies make the world a better place which is an increase from 66 % of the previous year. (A digitális jövő térképe – A map of digital future, 2002, p. 11.) 40 % of people seems to have no interest in using the internet. Internet users (21 % of the total population) show a satisfaction in the general sense, with the internet. The most positive opinions are about the quantity of information and the possible time-saving impact, the most negative are about the speed of internet connection. More than half of the respondents stated that the effectiveness of their work has improved by the use of internet. Cable-television and mobile phones are found in more than half of the households. Their spread is much wider than the internet. Rather than motivations, this gap between mediums is due to differences in the costs of usage and the fact that only 26 % of households have at least one computer.

5.3 Knowledge, innovations and the different groups of the societies[78]

Business firms and management

Since society means individuals' and their communities' roles and attitudes, a more detailed economic analysis is not provided here. Instead we move to the more personal level.

Obviously, business groups, their owners and managers are interested in using the achievements of science and technology to retain existing and to gain new markets with a central aim to bring profits to their enterprises. While this is an important force for enhancing scientific and technological development, there are cases when application of developments is abandoned because of weak profitability.

As competitiveness can be secured by gaining a technological advantage in many instances, generally owners and managers do have a positive attitude to scientific and technological development. Information and communication technologies have accelerated and intensified this process. While it is widely accepted that this leads to a decrease in the cost of that transactions and translating itself to a higher income for top managers, the more relevant issue in this study is the impact on working conditions and attitudes stemming from these conditions. It seems that frequent long-distance and international communication and data transmission do not compensate for increased competition in the era of globalisation: "greater overtime and travel" are reported. Managers can "make more informed decisions", but the increased speed of information exchange has "increased the overall pace of events." As those interviewed put it: "*We get less time to solve the problems. (...) There is less time available for creativity and relaxation*" The fact of always being contactable also increased pressure on individual managers. (Lochmann – Steger, 2002, pp. 343-344.) The delegation of decisions to lower managerial levels does increase pressure on managers which is in contrast to mood of celebrating less hierarchical and more democratic company organisation. Haddad (1996, p. 147.) stresses that "*even managers are resistant to technology adoption when the transition is not carefully planned*".

Other attitudes of managers originate from their responsibilities of introducing and managing technology at workplaces. In these cases, they face positive and negative attitudes to technology expressed by their sub-ordinates. Managers have to apply

[78] British Survey. (OST – Wellcome Trust, 2000) identified six groups in their relations to STI "Confident Believers" (17 % of the sample) tend to be interested in science, because of the benefits it brings, and they have faith in the regulatory system. They are usually well-off, well-educated and middle-aged. "Techno-philes" (20 % of the sample) have similarly positive attitudes toward science, but sceptical of politicians. They are well-educated. The "Supporters" (17 % of the total) tend to be amazed by science, feel confident enough to cope with rapid changes and believe that the government has got things under control. This is a relatively young group interested in natural sciences more than in others. The "Concerned" (13 % of the total) believe that science is important, but sceptical those of authority. 60 % of the women, and they are on average educational level. Those "Not Sure" (17 % of the total) are neither anti-science, nor proscience. They have the lowest household incomes and lowest education levels. The "Not for Me" group (15 % of the total) are not particularly interested in science and political issues. They are mainly over the age 65, partly middle-aged skilled workers, and less well-off women.

technology and this is different to simply using them. They have to identify themselves with and be motivated for these tasks. Therefore their acceptance of technology and science is crucial.

Managers are also responsible for building corporate responsibility in terms of the environmental and other types of impact on the society. They have to be able to communicate with the local and the general public.

Among owners and managers there are many who control small- and medium-sized enterprises. Their attitudes to science and technology can be positive, but also quite hostile. The positive attitudes may be found at firms which benefit from scientific and technological development or themselves involved actively in the process. However, in this is the case in Hungary, the majority of small- and medium-sized enterprises are not an integrated part of this process. From their viewpoint scientific and technological achievements' applications concentrate at large organisations hence they have a strong advantage. The response can be either a drive to catch-up, but also suspicion of or hostility toward science and technology.

The scientists

More and more scientists are getting aware that with the rise of a knowledge society is influencing their positions in society.

In theory, a knowledge society increases the chances of access to knowledge for a growing part of the society. If this is so in practice as well, the concentration of knowledge at the hands of scientists can weaken through an increasing access to internet (and other means of information flow) and a growing interest in controversial issues such as genetic engineering. The "ivory towers" of science are shaken. Of course, the internet and the mass media contain superficial, pseudo-scientific (and even anti-science) information as well, not really increasing (rather distorting) knowledge. Many scientists are rightly critical of the role of media. The danger here is to put the blame on an imaginary "ignorant society", treating in a patronising way all those who are not "experts". Dialogue is needed. And a dialogue with the public can contribute to reasserting a sane role and importance of science in the eyes of many people.

Ziman (1998) urges scientist to become more ethically sensitive, because "*their products become more tightly woven into social fabric*". However, as Ziman himself admits "*ethical issues always involve human "interests". Ethics is not just an abstract intellectual discipline*." Personal values and human needs are articulated by different layers of society sometimes against scientists.

The interaction between science and the social and economic system is further complicated by the fact that business interests have a growing influence on science. The state is accommodating itself to these interests more than before. Brenner's (1998) concerns are clear: "*If you know what sort of research is wanted by a committee you write your grant to satisfy your expectations, and if you know what the oligarchy* *believes is the correct view of a subject, you give your paper that slant.*" Ziman (1998) on the ownership of scientific achievements stresses: "*(...) industrial scientists do not, in general, "own" their research in the sense of undertaking projects of their own choosing and being free to publish their results entirely on their own initiative.*" Results of research financed by the private sector are being patented leaving thereby the free flow of information. The power of business is not seem to be matched by a consensus of scientists. The World Science Conference held in Hungary in 1999 omitted the question of patents from its final documents. At the same event Nobel-prize laureate physicist Leon Lederman voiced his concern: "*I am worrying that universities increasingly function as profit-making organisations.*" Alan Anderson said there that "*Many people see that discussions, exchange of ideas and free flow of thoughts so characteristic of universities are dying.*" (Fehér, 2002, p. 331.) One has to bear in mind that most scientists do not belong to circles of decision makers. They are paid as public servants or private employees and are under pressure of the day-to-day manifestation of business or state interests. Besides their commitment to science it is this condition that basically defines their motivations and attitudes. Their response to this situation ranges from fully accepting interests outside science (including the quitting public institutions in favour of more rewarding private firms) to publicly counter scientific independence against private interests.

Some academic communities, such as the one that drew up the Bologna Declaration stress "*the importance of education and educational co-operation in the strengthening of democratic societies.*" Similarly, universities' autonomy and independence are also emphasised. (van Ginkel, 2002, p. 348.)

Still, a major question is how scientist can match their strive for objectivity with arising social and political interests and concerns. The issue is far from being new, but challenging the scientific community sharper than ever.

Workers

The term worker is used rather than the term employee, because in this sub-chapter we discuss that majority of employees who do not have decision-making power over science and technology issues. This is the single largest part of the public, especially if we take into account that most of the students, pensioners and unemployed will be or were workers. Their attitudes, interests and roles are discussed in the context of the workplace. Most of the workers face technological rather than scientific issues when being employed. The emergence of knowledge society poses questions of distance-work, on-the-job training and lifelong learning as well. Professions are disappearing and new ones are born. Also, it has to be noted here, that workers in different industries and services use different types and levels of technology. It is partly due to this fact that inquiry to this area is usually occupation-specific and conclusions for workers in general are not easy to make.

Au-Enderwick (2000) aim to provide a general analysis on workers and managers combined attitudes towards technology adoption based on a survey of Hong Kong companies. According to their findings, experiences of previous adoption of technologies, the perceived benefits, enhanced value (e.g., quality image) and compatibility of the technology and the commitment of the technology's supplier influence positively the adoption of new technology. However this study does not differentiate between managerial and worker attitudes. According to a case study more focused on manufacturing (industrial) workers, "*attitudes are most strongly influenced by the position the employees hold in the organisational hierarchy, and by formal advance notification of the planned technology introduction (...) Organisational and not technological factors emerge as the strongest predictors of attitudes toward newly introduced equipment and systems.*" (Haddad, 1996, p. 145.) The same study refers to other sources on different attitudes originating from different levels of education and skills: "*Low-skill employees working in materials handling and assembly line functions overwhelmingly viewed the technology as a threat to their job security, while skilled trades employees were generally positive about the robots and saw opportunities to increase their knowledge and skills.*" Contrary to this there are findings that "*the most favourable attitudes toward the new technology were held by users who had high job involvement, regardless of whether they occupied high-skill or low-skill jobs*". (Haddad, 1996, p. 146.) In order to, at least partly, avoid the difficulties, communication between managers and workers, and in Haddad's words a "*congruence between the technical and organisational sub-systems*" is needed.

Associated with introduction of new technology, there is not only a fear of job losses, but also skill obsolescence. Much of the new assembly technology makes original skills unnecessary in manufacturing plants. Rather than vocational education, on-the-job training has gained ground recently and that is indeed quite important for the adoption of existing or new technology. New technology rearranges professions of white-collar workers as well. ICT can make white-collar professions obsolete as well. Training for the usage of new technology helps to turn attitudes to a more positive direction, but as discussed before, organisational set-up, management-employee relations, work cultures are more decisive factors.

It would be a mistake to confuse on-the-job training with lifelong learning, or even emphasis the connection between them. Workers that received on-the-job training a short while ago can be laid off by the companies. On-the-job training is no guarantee for job security. Contrary to this, lifelong learning is precisely about to prepare for difficult situations during working life. It includes adult education, re-training for the unemployed, self-learning and it should be supported by motivating workers for developing their knowledge and skills. Workers in their 40s and older are particularly vulnerable to insecurities in employment. In many cases they are discriminated based on their age. Also, their language and computer skills lag behind the young ones'. Not surprisingly, workers in their 40s and older are less motivated for learning than younger people. They have more family responsibilities (i.e., with less time and mobility), physically weaker and psychologically more exhausted than younger workers. Motivating them is a different and special task.

A review of two studies on nurses' attitudes towards new computer technology draws another down-to-earth picture of our topic. (ITIN, 2002) "*Outright refusal to use the systems was uncommon.*" Rather, the use of the computer system for documentation of care "*was often delayed in favour of other activities*" or because of lack of time – as the most typical answers sounded. Delay is also due to not using the new system the way its designers intended. In some cases more qualified nurses delegated the use of the system to unqualified staff, because "*using the systems was not seen by the community nurses as a "professional" activity*". The not fully successful implementation of the system is explained by the studies by the following factors:

- the system was perceived by the nurses as purely administrative; they got nothing back from it,
- the system was largely imposed on the nurses, with little user involvement in design and implementation,
- there were problems with the initial levels of computer literacy of nurses,
- concerns expressed by the nurses (working outside hospitals in local communities) that the system is monitoring their work, extend managerial control of their working.

Generally, a "*resistive compliance*" is reported with no general resistance but lots of small resistances. According to the study, similar attitudes found among bank workers to total quality management. A survey of a Hungarian hospital and nearby health institutions' workers show a more than 90 % acceptance, in fact need, of computer education in higher and adult education. (Virányi-Zrínyi-Baráthné, 2001) Thus, the partial resistance to new technology originates from workplace experiences rather than an opposition to learning new technology. These findings have some general implications for white-collar workers and public servants in unified and well-defined professions.

In Hungary, there have not been adverse attitudes towards innovations among industrial workers. Strongly increasing unemployment rate of the 1990s has made workers to accept productivity-increases based on technology new to them and the pressure for learning quickly the use of technologies introduced by foreign investors. A negative attitude can appear on behalf of people who are overeducated for the job they do. Skilled workers and even engineers are reported to do semi-skilled level jobs. Education above the required skills is emerging as an issue, with debates started whether overeducated workers are frustrated hence less productive, or more work- and career-minded helping the companies they employed at. (Büchel, F. 2002)

Distance work is frequently discussed in connection with knowledge society. The emergence of it depends rather on company strategies and the available necessary technologies than individual motivations of possible workers. Although there may be various forms of it in terms of required skills, the usual case in Hungary is data recording (requiring only a basic level of computer literacy) done by students or done as part-time or temporary work. Therefore the motivations for doing the job and the role of it do not really reflect latest developments or interest in ICT. Attitudes can change, because "*in the second year they feel lonely, need a company of people; in the third year they get depressed*". (Enyedi – Tamási, 2001, p. 4.)

Students and education

The first occasion one meets with science is in the school. Students learn technology in vocational education (conducted in secondary schools in Hungary) and in tertiary education. The curriculum and the way it is taught can determine one's interest and attitude for long years to come. The educational system has to cope with several challenges. The quick pace of technological development at future workplaces of students is not easy to match by the education system. Guile (2001, p. 475.) stresses arguments of Young (1998) that "*the shift towards a "knowledge economy" has problematicised the traditional link between qualifications and employment. (...) employers are no longer using qualifications to select individuals for fixed and routinised roles, nor for stable employment. (...) "knowledge economies" are characterised by increasingly fluid occupational structures, they are generating the need for new types and combinations of knowledge and skill.*"

The need to develop basic skills, computer and language skills, and creativity is regarded as more important than before. Guile (2001, p. 476.) goes deeper arguing that "knowledge ability" should become a basis for employability, i.e., "*relating theoretical and practical learning to one another to enable connections to be made between workplace and formal learning; learning how to use information and communication technology as a resource for communicating with others (...) and developing a transformative rather than an informative relationship with the world.*" To simplify this argument it can be said that instead of counter posing the developing of skills to the teaching of more conventional knowledge, methods should be changed to move away from simply "entering data" into students heads. It is a warning sign that students in Hungary spend more and more time with learning than those in most OECD countries and are exhausted which leads to losing interest in gaining knowledge and escaping into low-level, "relaxing" entertainment. The PISA-survey conducted in the spring of 2000 has also revealed that Hungarian pupils are below the OECD average in terms of reading and understanding texts and mathematics, while knowledge in natural sciences shows a better picture. (A PISA-survey..., 2003, p. 10.)

Having the above problems in mind, no wonder that young people's interest in natural sciences and engineering is weakening (in Hungary an exception is informatics). Science is perceived as boring and abstract by many students. Also, the controversial issues discussed before in this study are reaching students who are exposed to the media and the internet more than before and usually more strongly than older generations. Students tend to use ICT more than adults in their free time and with some delay also started to realise its possibilities for learning. However this latter process has started only recently in Hungary (and the spread of internet lags behind most OECD countries), but students' attitudes to ICT in the context of learning are examined based on a survey at a London university. (Shaw-Marlow, 1999) The results show "theorist" minded students are less positive on ICT; many students prefer teacher-led (and other more personal and traditional forms of) education rather than the use of ICT. First-year students have a more positive perception of ICT supported learning indicating a quick pace of the spread of ICT and positive motivations towards it in the examined community.

On the one hand, science and technology subjects should be taught in a way that emphasises its link with real life, its link with other disciplines and in a way that raises interest. One of the important functions of education is to motivate students to gain more knowledge of their own choice, to self-learning and to train them how all these can be done effectively given the enormous flow of information. These latter priorities should serve as a motivating force for students to gain more knowledge on science and technology issues.

The tripling of the number of students in tertiary education in Hungary may have an impact on attitudes and motivations in the working life. This will come through a possible increase in the number of unemployed with a diploma and an increase of over-educated workforce. There are also worries about the decreasing quality of tertiary education and students' motivations for learning can deteriorate because of lower quality.

Adult education is an important priority in a knowledge society. The current Hungarian government has declared a strong emphasis on it. Attitudes toward science and technology and motivations for learning are more difficult to improve in case of many adults who have a more developed, but at the same time, more rigid view of the world. Contrary to the case of youngsters, new technologies can be felt as alien by older adults.

Teacher education is to be reformed in order to cope with the above challenges. Teachers should be motivated in their job as well. In fact, many of them realised long time ago that in this profession lifelong learning and openness to new issues of science and technology are a must.

5.4 Can the public influence the sphere of science and technology?

In a knowledge-based society there can be no passive role for the public regarding science and technology. However, in a world economy under liberalisation, with strong transnational corporations, science and technology policies on the national level are redesigned and weakened. Regarding environmental sustainability a study financed by the EU has clearly stated that "*there has been a transfer of responsibility in many areas of environmental science and technology policy from the public to the private sectors, and a decrease in state involvement in research and innovation. Privatisation has tended to limit public access to decision-making and to the setting of policy agendas.*" (PESTO, 1999, p. 10.) Even this having in mind it can be said that the role of the state in shaping science and technology policies has shifted, relatively, to the local and the international level creating chances for public participation on the local level and a growing pressure on the international level. While nation states' role diminishes somewhat on the national level, state agencies themselves initiate public participation schemes on local level.

The projects described here below are proposed and organised by state agencies, private institutions, NGOs and by their co-operation in the EU, the US, Canada and

Australia in most instances. The EU seems to have a leading and innovative role in initiating such projects. Besides to the projects depicted here below, the UN-initiated Local Agenda 21 activities (of wide ranging issues of sustainable development) involving local governments and the public have to be mentioned as well.

Another dimension is that the connection between civic organisations and the population can improve through the use of the Internet and the exchange of knowledge can intensify. There has also a new actor appeared named 'policy entrepreneur' (with a background in civic organisations and administrative structure as well) managing, as a kind of mediator, the process of public participation in shaping local policies. (PESTO, 1999)

Civil society

Recently, civic organisations and NGOs seem to assert a stronger role in influencing public policies and private sector's activities as well. For many involved in such organisations, this is a response, a search for a balancing force in an era where public policy and private sector's decisions are becoming more distant from the general public, because of globalisation. In many cases civic organisations disseminate ideas and proposals that fall outside mainstream thinking and policies. Their knowledge and expertise are increasing, more and more of them take part in local professional activities and international development assistance projects, while the number of “counter-experts” is also growing. Science and technology issues are not really in the focus of NGO activities, except for ecological, aboriginal (in some cases peasant) organisations and local communities that usually warn of the detrimental impact of certain technologies (and sometimes science) on the environment or local communities' lifestyle.

Trade unions face a double challenge of re-gaining lost membership and pressure force, while confronting new conditions and new types of work that have appeared creating a need to defend new types of workers’ interests on the company level. On the national and international level, trade unions have very few opportunities to influence science and technology policies. In Hungary, trade unions are not invited to formally discuss science and technology on a national level with the government and the employers. (The tripartite structure has been very weak in Hungary even in negotiating core aspects of working life.) Issues on the micro-level seem to be more closely felt by workers creating more pressure on union leaders to act. On this local level, union leaders and activists seem not to be negative toward science and technology, with the exception when technological developments have a negative impact on workers’ interests.

Employers’ organisations can provide information for the state about the real demand for knowledge and skills based on the level of technology and the process of innovation on the micro-economic level. It should be remembered however, that employers’ organisation act also as a lobby to direct science and technology policies into ways that benefit them, making the biased on the issues.

We can witness a growing number of civic organisations representing people that are common in their special conditions (ethnic minorities, invalids etc.). Here, national policies are still something to influence, because welfare and ethnic policies are usually defined on that level. As for science and technology these civic organisations and NGOs can provide new areas, priorities and new viewpoints of research and its applications, together with providing their own information and accumulated knowledge on such matters.

Professional organisations can have a very positive role in spreading information and knowledge of science and technology in their special fields. They can very much complement state-owned institution's similar activities and co-operate with them as well. The spread of real and un-biased scientific knowledge must be granted with more opportunity. The credibility of professional organisations is also considered high.

Organisations based on same or similar lifestyle, sports, cultural interests, hobby or age contribute to utilise free time for personal advancement of skills and knowledge in a positive way.

NGO networks, non-profit "service providers", foundations, charity organisations play a role to enhance the efficiency, know-how and finances of the above mentioned organisations, acting also as a bridge between members and non-members (i.e., the rest of the public) of organisations.

Community-based research

Community-based research (CBR) is a collaborative partnership between researcher and community. Instead of imposing the application of science on citizens it is "*conducted by, or in participation with, the community that is affected by the problem the research attempts to address.*" (Chopyak-Levesque, 2002, p. 159.) This method is applied in many infrastructural projects in developing countries.

Consensus conferences

The Danish *consensus conference process allows citizens to make policy recommendations about specific scientific and technological developments, and those recommendations are then included in the process by which the Danish Parliament makes its decisions.* (Chopyak-Levesque, 2002, p. 160.) Usually at one conference 12–15 citizens involved to learn and deliberate about a complex science and technology issue. Then the outcome is cross-examined and commented by a panel of experts that develops a policy statement on the issue, which is presented to policy makers and the general public. In the US, Canada consensus conferences were organised in the last six years on topics such as gene therapy, traffic issues, telecommuting and transportation and "*(...) when citizens are given relevant information, they can make coherent and well-thought-out recommendations on complex science and technology issues. (...) Furthermore, consensus conferences draw general attention to the particular issue they are addressing, and bring the issue into public debate.*" (Chopyak-Levesque, 2002, p. 161.)

Scenario workshops

This method is used for urban planning, bringing together a diverse set of participants to discuss and evaluate the impact of multiple technological choices on a particular setting. Four scenarios are drawn about a day in the life of a resident in 20 years from now. Each scenario describes alternative ways of solving particular problems, such as energy, water, housing and transportation. These are visions rather than predictions. The workshop lasts for a whole weekend, with participants developing their own vision of the future, using "role play" and the scenarios as the basis for discussion. This method is about debating visions of the future. So far it is done only in Europe and in a smaller number of cases, compared to consensus conferences. (Chopyak-Levesque, 2002, p. 162.)

Participatory Designs

The Joint Application Design (JAD) method was derived from IBM's initiative in 1977 to involve users of computer systems in developing new technology. Through a series of discussions with users, a design document is produced based on a consensus. The motives for this method are improving quality, reducing costs and suiting the needs of users. It is controlled by those designing and managing technologies rather than by users. JAD *is unwilling to call into question or transform the fundamental technical rationality, practices and political organisation of that process*, more or less contrary to earlier mentioned schemes. (Asaro, 2000, p. 264.)

According to Asaro (2000) *European Participatory Design* is originating from the Norwegian Industrial Democracy Program which included four experiments. Based on them a Scandinavian trade union-centered program and a British work group oriented program (socio-technical systems design) has started. Both of them had the aim of a *democratic reform of workplace technology*. These programs were pilot projects but were also predecessors of the Quality of Working Life movement and further popularised the idea of humanising work which was supported by significant state resources in Germany during the 1970s. The "second generation" of the Scandinavian project has appeared in the Swedish-Danish UTOPIA scheme in 1981 and "*targeted technological development as a prospective site for user involvement and influence*" implying a more radical aim of creating "*alternative technologies designed around workers' interests.*" based partly on the Marxist critique that existing technologies serve the dehumanisation of work and subordinating workers. (Asaro, 2000, p. 267.) The British project went on during the 1980s as well and led to conclusions that technology can be "*seen as also being able to promote workers' interest by making work more interesting, reintroducing skill*" with feasible autonomous work groups in which workers are allowed to spontaneously develop their own work routines, make decisions and change tasks with little or no supervision. Here participation is about direct control over technology. (Asaro, 2000, pp. 257–290.)

Interestingly, the drive for more efficiency and flexibility of work organisations during 1980s and 1990s was sometimes done by enhancing workers' participation in technology issues. Best known is the Total Quality Management. However these are quite distinct from the above mentioned participatory projects both in their aims and methods. The aims are clearly centered around quality and efficiency, the methods speak about the worker being less autonomous, motivated for controlling himself and making proposals for improving the technology rather than improving his/her own technology-related working conditions.

Other specific methods of public participation

The advocates of the Precautionary Principle in the US demand public participation in research, science and technology decision making with a democratic examination of possible alternatives of applications and precautionary measures if an activity raises threats of harms to human health and the environment. (Chopyak – Levesque, 2002, p. 162.)

The "Infralab" (Dutch Infrastructure Laboratory, established in 1994, as a special division of the Ministry of Transport) is an attempt to foster citizen involvement in infrastructure decisions. (PESTO, 1999, p. 17-18.) There are three phases here. In the first the problem concerning the planned infrastructure project is identified by hearing the voice of the customer through discussions between users of the infrastructure, local residents and planners. Then there is a workshop to negotiate and elaborate solutions. Finally, planners and experts start to execute the project with ongoing public consultations and monitoring. Since the launch of this scheme, five large infrastructure projects have started in which the method has been gradually integrated.

Further methods to be mentioned are: citizen juries, feedback panels, public participation workshops, questionnaires being quite similar, although less institutionalised, compared to the above mentioned examples.

It is evident from the above trends that the influence of science technology and innovations on people's lives is growing. While recent benefits to humanity are unparalleled in the history of the human species, in some instances the impact has been harmful or the long-term effects give causes for serious concerns. Within the general public, there is certain measure of mistrust and even fear of science and technology. Some is based on public experience, but much is the consequence of a significant communications gap between scientists, firms and the different groups and institutions of the society. Many reasons are advanced for these attitudes: public ignorance or misunderstanding of science, inaccurate or biased media coverage, uneven distribution of the costs and benefits of science among different sub-groups in society, lack of public control over the applications of S&T, and the inability of some scientists to communicate ideas in plain language. In part, the concern of the public stems from the belief that some individuals and communities will be the ones to suffer the indirect negative consequences of technical innovations introduced to benefit only a privileged minority. STI policies should take into account the social consequences of the technological applications or dissemination of the results of R&D, including the potential hazards.

There are a few main issue areas which must be taken into account in the future, also in the KNOGG countries. (a) The future of the individuals on the path toward the knowledge based society depends to a great extent on the opportunities of obtaining knowledge. Only a learning society can “climb” higher on the ladder of knowledge. (b) Equal opportunities must be offered by the society in obtaining knowledge. The gender aspects of these process are particularly important. (c) The example of the some of the KNOGG countries indicate that a social consensus is an important condition of success. This requires greater transparency in STI policies and effective participation of people in the democratic process. (d) There are also many ethical issues involved, from the honesty of science to the honouring of public interests in application and marketing. (e) International co-operation should be also developed such a way, that the interests of the smaller and weaker partners will be taken into account. The process of co-operation must be more effective in promoting the catching up of the lagging behind countries.

6. Summary and conclusions

The Commission's 2000 Communication *Innovation in a knowledge-driven economy*[79] identified five priorities to steer Member State and EU-level actions topromote innovation: (1) Coherence of innovation policies, (2) A regulatory framework conducive to innovation, (3) Encourage the creation and growth of innovative enterprises, (4) Improve key interfaces in the innovation system, and (5) A society open to innovation. In the framework of the KNOGG program and particularly in WP4, one of the goals has been the analysis of the national system of innovations and the national policies from the perspectives of these priorities.

Beyond the introduction and the conclusions, there are four main parts of this paper. The first part is a discussion on *the influence of the domestic and international environment on STI policies in Europe at the beginning of the 21st century and the perspectives of the small countries. It is dealing with such important changes as the new trends* in science, technology, globalisation and the main aspects of the transition to a knowledge based economy. The second part is an analytical overview of *the main conclusions of WP1, WP2 and WP3 and of the issues related to the progress toward an European Research Area from the perspective of national policies.* The third part is looking at *the sources of success* and *failures in national STI policies* including the relevance of the main indicators, quantity and quality, the issues of the management of knowledge. The fourth part is dealing with the role of the societies in STI: *public perceptions concerning R&D and innovations. The role of the public in the development of science, technology and innovations in the KNOGG countries and beyond.*

1. *The identification of the main issues should be fundamentally important stage of STI policy development at all level. It includes the analysis of the national capabilities, the different contributing factors and also the emerging national, regional and global environment.* This is an essential step before setting the science policy priorities programs. The framework for the elaboration of policies for the decisions on the tools of implementation, for the necessary institutional reforms and the participation in international co-operation regimes is the national system of innovations. A National Innovation System (NIS) refers to the system of Knowledge Producers and Knowledge Users and to their interactions, together with the set of government policies and infrastructural provisions that impinge on their activities. A healthy NIS enjoys a vigorous interaction between the education system, industrial base, development agencies and the financial system. This generates an environment which both encourages and supports companies to become ever more innovative

2. The most important difference between the national innovation system of the larger and smaller countries is the greater dependence on the external sources of knowledge and innovations. The processes of globalisation and regional integration

[79] COM(2000) 567.

have a much greater influence on the small countries. There are also other, important mainly structural differences. There are differences rooted in historical traditions and geopolitical situations. The different policy models, or dimensions even in the KNOGG countries are in fact reflecting specific efforts aiming at the adaptation to different situations or the results of interacting social, economic and technical changes within the national economic space or in the international environment. The evolving international environment for all the countries, participating in the KNOGG project includes the progress toward a regional system of innovation in the framework of the European Union. The realisation of the goals related to the establishment of the European Research Area will imply radical changes. It may open new opportunities but may also create problems for the small countries. An all European infrastructure may stimulate more efficiently research and development promote diffusion. The co-ordination and harmonisation of national efforts may be resulting in a more efficient utilisation of the existing capabilities. The progress toward the creation of an "all-European" venture capital fund may help the entrepreneurs in the small countries.

3. *The changes in the technological system, particularly as the results of the information and telecommunication technology, are so far-reaching in their effects that they have a major influence on the functioning of the entire economy also in the KNOGG participant countries.* Some of the main changes in the "traditional" areas are particularly important like the reduced lead time for new product, the reduced inventories, the more accurate control over production and better quality information for management, the better utilisation of high cost technology, reduced overhead costs, improved delivery performance. The most important innovations of the next two or the decades will most probably take place in four basic areas: information technology, bio-technology, micro-electromechanics and the closely related nanotechnology. These technologies and their combinations will have a major impact on all areas of human activities. The growth of computing power, the smarter software, the near universal access to information and to many sources of knowledge will be linking most part of the world. Information technology will make most of the socio-economic processes interactive. In the developed part of the world a special "personal infosphere" will develop around the individuals, which will be tailored to their individual needs. This will be also an important source of empowerment in many areas of their life.

   The promises of biotechnology are even more important for human beings. There are some aspects of biotechnology, like its use for warfare, cloning, genetical engineering of human beings or GM food production will remain controversial, but their development will continue anyway. The role of biotechnology in the improvement of human health and in pharmaceuticals will open qualitatively new areas for treatment of different diseases, enhancing for example human immune response.

   There will be a dramatic increase in the capabilities of micro-electromechanic devices. A revolutionary development in the field of nanotechnology, particularly those technologies which operate on the frontiers of information technologies and biotechnology will open new areas in medicine, scientific research, in transport, industry and agriculture. An other important promise of STI may be realised in the global energy economy.

4. *One of the very important characteristics of the evolving new technologies has been an unprecedentedly large qualitative difference between the new technologies and those representing the earlier technological eras in the products and processes which they are resulting in and also in their influence on productivity changes.* They expanded the productive frontiers of individuals, firms and of the countries at a historically unprecedented rate already at a rather early stage of the changes. *Their global spread has been much faster than of the key technologies of the earlier stages. This is due to several new socio-economic factors, like the faster development of the educational system and the internationalisation of science and education, the information revolution and its implications on the patterns of consumption and production etc. A key role is played by the transnational corporations, which are the most important global agents of the diffusion of new technologies.* The role of science and technology in international competition and the related national policies have been also accelerating the diffusion process. The transition to the new technological era on global scale, including the KNOGG countries, is however still a long term, complex and uneven process.

5. There are major changes in the global environment of science, technology and innovations. *There has been an increase in the role of the market forces in the demand for research and development, the drive for greater efficiency and economic rationality is reshaping the role of science and making national science policies more pragmatic and market oriented. Several components of those policies, such as the selection of research priorities and the integration of science policies with other social objectives (for instance, environmental protection and economic development), are being redefined to secure higher yields.* The R&D policies of large corporations, which formulate objectives to correspond to future changes in demand, are also being influenced by these changes. Many firms shifted a greater proportion of resources away from long term investments toward shorter term projects. R&D for immediate problem solving or near term development is prioritised over long term goals. A growing part of basic research in certain industries is directed toward product development. The growing commodification of science is also related on one hand to the high costs of research and on the other hand to the sources of its financing. The increasing role of private sources presupposes the private ownership over its results. Many private research universities realise large revenues from their patents. Some of the experts suggested that moving science closer to the market may promote more efficient and more effective mechanisms for advancing commercial technologies and knowledge for practical use. Others have characterised this situation however as the "end of the era of great science." This may be an overly pessimistic view. Expenditures on science will have to increase also in the future, not only in those areas, which serve directly applications and competitiveness. There are however some important questions. Coupling research to commercial interests does not necessarily provide

incentives for generating new knowledge in those areas where the "social usefulness" is the main motive. This also implies however the shrinking of that part of knowledge which can be considered as "public good". The public character of scientific knowledge may be under a growing threat. This may adversely influence basic research which cannot be directly commercialised. It may also adversely influence the diffusion of new knowledge. Some of the international agreements in WTO and national legal systems may be resulting in the greater protection of knowledge through patents or greater secrecy in order to provide incentives for investing in knowledge production. Other forms of protection are also envisaged in the TRIPS agreement of WTO. All these imply major new tasks and challenges to government policies. Many issues of research, development and innovation became also important tasks for the different international intergovernmental organisations. In any case, the greater privatisation of R&D is increasing the role of the patent system. The development of the national system of intellectual property protection including the patent system should occupy a more important role in STI policies also in some of the small European countries.

6. The new era is increasingly characterised as the age of the knowledge based economy or society. *There are three main approaches to the new role of knowledge. First, there are those who consider knowledge as quantitatively and qualitatively more important factor in economic growth than ever before. There is an other view, according to which knowledge as a commodity has become more important than in the past, and the essence of the knowledge based economy is the knowledge market, which is based on the information revolution. There is also an argument that codified knowledge became more important than the tacit, person-incorporated knowledge in conduction economic activities. One must add however certain qualifications to this views.* First, the role of knowledge has always been important. Since the earliest analysis of modern economic growth, knowledge and technology have been recognised as factors of key importance. The importance of knowledge and information in the contemporary economy has long been established. The notion that information and knowledge are of central importance both in the process of production, as well as an essential part or the final commodity produced, is almost a platitude and it always has had some weight. Knowledge was needed to make a spear, as well as to make a microchip. What has changed, apparently, are the quantity, the quality, and the density of knowledge and information, the speed in which it circulates and changes, the proportion of it which is embodied in the final product. *Knowledge, in a "knowledge based" economy or society did not and would not replace the other two factors of production: labour and capital and the economic and entrepreneurial infrastructure.* It has become however a very important condition for the increasing efficiency of the other factors. It has become a major source of competitive advantages. Knowledge is only a necessary but not sufficient condition for market success either. Only when it leads to marketable technological innovation does knowledge have value for the firm. Firms must be able to finance new technology ventures, to hire and train skilled scientists, engineers, managers and production workers, they have to be able to protect their innovations from imitators, they have

to acquire complementary skills to make their technologies useful and they have to gain market acceptance. Firms increasingly depend on specialised knowledge in a number of areas to provide a continuously replenish able source of competitive advantages.

7. It is an important question also from the perspectives of the KNOGG participants, *why some countries invest a larger proportion of their GDP in R&D than others?* There may be different explanations. One of the explanations is based on the character of specialisation of the different countries. According to this view, countries, which are specialised to high technology industries, to goods and services which are research intensive,[80] will have to invest more in R&D. This explanation is disregarding the fact that in order to develop research intensive production and services, the countries need already a well developed research infrastructure and high investments in R&D and education. An other explanation is based on the size and character of the firms. Countries, which are the home of large international or transnational corporations may have the resources, the scale available and the threshold of R&D infrastructure. This explanation is partially relevant. It has particular importance in the smaller countries, like the Netherlands, Finland from among the KNOGG participants. A third explanation is based on the cultural tradition. A fourth explanation is focusing on the character of the innovation policies. The emphasis on imported technology through FDI or the preference given to the purchases of foreign licenses and know how may not stimulate national R and D investments. The absorptive capacities of the countries must be also taken into account. The diffusion models may also influence the size and structure of R&D expenditure. There may be of course temporary setbacks due to economic difficulties. *All these problems suggest that the anticipated 3 per cent share of R&D expenditures in GDP as it has been suggested in Lisbon should be dealt with some caution in the case of certain countries.*

8. Globalisation has a major influence on many aspects of STI. In the KNOGG framework the main emphasis has been placed on the analysis of macro policy aspects of the globalisation process in the participant countries. Knowledge flows always existed between different human communities in a great variety of forms and through different channels and the KNOGG countries have been not only exposed to these flows, but also contributed in many ways. *Science has been one of the most internationalised "sector" also in the KNOGG countries.* During the second half of the 20th century internationalisation process of their science and technology base has become more intensive. They have been influenced at a different scale to the consequences of the greater mobility of people, international education, information and communication technologies, the internationalisation of firms and particularly the role of transnational corporations. *The European Union has become an important medium for promoting internationalisation of STI in Europe and transmitting global processes.* Globalisation of STI implies important opportunities for the small countries also as a potential source of new knowledge.

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[80] See: Eaton, J. and Kortum, S.: International Technology Diffusion. International Economic Review 40. No. 3, May 1999. pp. 1-33.

In a globalising knowledge system however it is very easy to become marginalised in the main flows of knowledge. All these imply new challenges and tasks for public policy. *Instruments, which promote the inflow of new knowledge, like measures which upgrade the national R&D infrastructure, expand the national reservoir of highly skilled people, attract high technology research and production activities of the transnational corporations are particularly important for small countries in order to be able to use those opportunities which are offered by the globalisation process of STI.* The understanding of the relationships between different areas of the EU policies is very important. From among the different policy areas it is for example essential to understand the interrelations between innovation, R&D and competition policies.

9. In WP1, WP2 and WP3 it has been underlined that there are important general conclusions for STI policies, irrespectively the size of the countries and there are size specific aspects of STI policies. A general proposition of the new models of economic growth is for example the great importance of STI in the development process and particularly in the increase of output and productivity. Innovations can assume many forms also in the small countries, including incremental improvements to existing products. Science plays a critical role in innovations, but it is not the only driver of products, processes and services. It is also a general conclusion, based on empirical experiences and studies that the linear model of innovations, which implies that innovation proceeds sequentially from new scientific discoveries, processes and services is limited in its descriptive and predictive power. History, institutions and geography all shape the development of knowledge-based economies. History matters because increasing returns generate positive feed-backs that tend to cause economies to "lock in" to particular technologies and locations. Development is in part chaotic because small events at critical times can have persistent, long term impacts on patterns of economic activity. Institutions matter because they shape the environment for the production and employment of new knowledge. Societies that generate and tolerate new ideas, and continuously adapt to changing economic and technological circumstances are a precondition to sustained economic growth. Geography matters because knowledge doesn't move without frictions among economic actors. Important parts of knowledge are tacit and embedded in the routines of individuals and organisations in different places. Markets fail to produce enough knowledge because innovators cannot capture all the gains associated with creating new knowledge. And because knowledge can be infinitely reused at zero marginal cost, firms who use knowledge in production can earn quasimonopoly profits. All forms of knowledge, from big science to better ways to sew a shirt exhibit these properties and contribute to growth. Economies with widespread increasing returns are unlikely to develop along a unique equilibrium path. Instead, development is likely to be a process of creative destruction, with a succession of monopolistically competitive technologies and firms, as originally described by Joseph Schumpeter. Markets alone may not converge on a single most efficient solution, and technological and regional development will tend to exhibit path dependence. Governments and business both play an important role in developing the

environment conducive to R&D and in establishing the environment and infrastructure necessary in STI. The public mission of governments and their concrete role in influenced by the political process and the socio-economic environment. Small country experiences indicate that policies in these countries should not copy mechanically even the generally valid experiences. The role of education, the flexibility and openness of the institutions, the active participation in the international flow of information and knowledge, the integration into international sources of technology and innovations has much greater significance for the small states.

10. STI policies may be interpreted as attempts to achieve simultaneously diverse social and economic goals which cannot be easily reconciled or even endanger each other. There has been a general agreement in the framework of the KNOGG project about the main tasks of science, technology and innovation policy. *The primary task is to ensure a balanced development of the innovation system, in harmony with the main social and economic goals in the given country. These goals usually include the increase of competitiveness, the improvement of the standard of living, contribution to employment creation etc. These goals underline the importance of harmonisation of STI policies with other policy areas. There are a number of social actors the interests of which are directly influenced by the instruments of implementation and by the outcomes of STI policies.* The main institutional aspects, mechanisms, direct and indirect instruments of STI policies in general and in the KNOGG countries have been dealt with in WP2.[81] It was underlined that the main task of the institutional hierarchy of STI policies is the development and implementation effective STI strategies, including the constant improvement of policy instruments and mechanisms. There is also a broad area of concrete tasks like the increase of the quantity and the improvement of the quality of human resources, science education and training especially at secondary and tertiary level including teacher training, developing science and technology infrastructure and improve access to S&T know-how. The STI institutions of the governments should promote linkages between universities and industries, and commercialisation of public research findings. They should help promote diffusion and reduce the and barriers to knowledge transfer, promote international co-operation in STI and the national participation in international organisations and programs. An other important aspect of STI policies is related to gender: the task of improving the participation of women. Governments should also assist institutions which are dealing with the social understanding and popularisation of science and technology.

11. *The specific role of actors and policies related to STI is changing over the time. The evolving knowledge society requires a new kind of flexibility, innovation and adapt-ability to which least in principle, the smaller countries and smaller firms are better equipped. Knowledge at the same time magnifies some of the advantages of larger states and big business. These are capital requirements, the demand for*

[81] See: Cogan J. and McDevitt J.: Science, Technology and Innovation Policies in Selected Small European Countries. Government Institute for Economic Research. Helsinki, 2003.

the "critical mass" the ability to obtain and coordinate resources with the market needs, the "visionary direction from the top" the capabilities to use such instruments in competition as brand names, research, development and marketing networks etc. There are no exclusive and generally valid models which would be the most effective in promoting progress toward a knowledge-based society, even in the case of small countries. There may be different alternatives. Some of them may correspond better to the logic of the specific country to its economic and human conditions to its market, to the patterns of its capital accumulation, demand and output.

12. Firms are the key actors of international competition in the global market. Competitiveness is increasingly dependent on the ability of firms to use and develop new technology effectively. Access to the new "core technologies" has become crucially important to international competitiveness. Technological development on the level of the firms depends on internal and external factors. The external factors include the interactions with other firms. Particularly with those which concentrate global technological capabilities. The large transnational corporations own most of the production technologies available in the world. They are therefore the main technology suppliers to all countries. In the early 1990s 80 per cent of the total receipts for technology supplied by the US was on the account of TNCs. In Europe, the proportion of TNCs was 50 per cent in the total receipt for technology. In the small countries the role of transnational corporations is particularly important, because of their role in STI and the international diffusion of innovations. The role of transnational corporation in the development of STI capacities is also related to government policies and institutions through a number of channels. This is reflected both in the analytical part and in the conclusions of WP3 which has been dealing with the role of the corporate sector and particularly with the role of TNCs. The conclusions of WP3 underline that the relationship between small European countries, foreign direct investment and technology development is complex. *The greater openness of small countries to FDI as compared with large countries makes FDI an important mechanism to increase the knowledge base of small European countries. Small developed countries are squeezed between two developments. First, the growing complexity of new core technologies and limited resources impede the development of an extensive R&D infrastructure. So-called national treasure R&D is hard to achieve in small countries. The other development is that competition in low and medium tech products is increasingly dominated by the Newly Industrialising Countries. This suggests an increasing technology gap between large and small developed countries. At the same time technology is increasingly internationalised in the last decade. The way out of this squeeze for small countries is to make optimal use of the internationalisation of R&D*, which offers many opportunities for small European countries to upgrade their knowledge base if they implement the right policies. Attracting new investments for stimulation the local R&D of the affiliates of foreign firms and for providing skilled and better-paid jobs is a legitimate goal for the governments in the KNOGG countries. It is essential however to strengthen simultaneously the STI framework for local business and to identify mechanisms

for a more efficient innovation process, to create incentives for spin-off companies from knowledge centres at universities and larger companies. One main element in such policies is to have a strong local R&D infrastructure including the university system. Many channels for collaboration between international and national firms and universities on research already exist. These have helped to build up new competencies in companies.

13. International collaboration in research, involving universities, research centres and industry, has long been supported by the European Union (EU). Since its earliest days, the EU has had to justify its actions in terms of the additional value they might have over the actions of Member States. The positive reasons to collaborate are fairly obvious. First, progress is fastest and most cost-effective when it draws upon knowledge wherever it may be found. The experience at the European Laboratory for Particle Physics (CERN) shows that when you put together scientists and engineers who have been trained in different traditions and look at problems from different points of view, often the whole is better than the sum of the parts and they come up with original ideas for solving problems. Second, many areas of research require broad interdisciplinary approaches and international collaboration may be essential in order to reach the necessary critical mass. Third, there are some activities that are beyond the means of most – in fact probably all – individual countries, so that if we want to do this research we must collaborate. Furthermore, even if an activity is affordable nationally, international collaboration may be desirable in order to reduce costs and avoid duplication. Finally collaboration has a valuable human and political role in bringing people together, which it is appropriate to emphasise. Co-operation has been organised since 1984 within successive multinational framework programmes. Community research activities are designed to complement those of the EU's Member States and work towards closer integration of Europe's scientific and industrial communities. The central objectives of Community research policy are to reinforce and mobilise the Union's scientific and technological capabilities in support of industry, the economy and quality of life.

14. The role of the European Union in promoting complex and comprehensive co-operation between countries, national and international firms, national research centres universities will be more important in the future. It will influence all the main actors in STI. In order to achieve the anticipated goals, the European Union and its present and future member states will have to implement important policy changes, in a number of areas. One can agree with the following introductory statement of an important EU document

> "*Achieving an innovation performance that makes the European Union a world reference for innovation represents an enormous opportunity that can translate into raised living standards over the coming years. Progress towards such a more innovative European economy is however proving tentative and fragile. Enhancing innovation is a cornerstone of the strategy to meet the target agreed by the European Council in Lisbon in March 2000 of the Union becoming the most competitive and dynamic knowledge-based*

> *economy by the end of the decade. Yet the Commission's 2003 Spring Report, which assesses progress towards the Lisbon goal, stresses that much remains to be done, particularly in the area of knowledge and innovation signalled as the central priority for the coming year in taking the Lisbon strategy forward."*

The creation of an European Research Area is an important goal which is being discussed both the EU and also in the present and future member states. *In the framework of EU, where there is also a high concentration of research to Germany, France and the UK, it will be even more important in the future to design specific "stairways" for the smaller countries which would facilitate their active participation in the horizontal structure of an evolving ERA: bi- and multilateral programs and projects, special strategic alliances. The creation of the European Research Area may be resulting in important change of the RTD policy formation and implementation in Europe through higher budgets, higher concentration of competencies and more co-ordinated national programs. It can play a crucial role in the more organic integration of the Candidate Countries into the European R&D structure. There are certain conclusions, important from the point of view of the process. One is related to the experiences of the Framework Programme, with its additionality and emphasis on excellence, posed already series challenges for countries whose absorptive capacities lag behind. Of particular importance here is the capacity of the country to compete successfully for funds and the capacity of the economy and society to absorb and productively utilise new knowledge, science and technology. An other key issue is that ERA should be resulting in more networking than new institutions. ERA should not be just an additional institution in the already existing proliferation of international networks and programs, of the so-called "acronym jungle". It must have not only the support of EU but also of the national governments of the larger countries. It should be the basis for the formation of true international partnerships that allow scientists in different disciplines and countries to fully support each other's aims and share resources and management duties to mutual advantage.*

There are some important lesson, learned from the past experiences of European co-operation schemes, which must be taken into account in this program. First, although it is nice to start international collaborations on green-field sites – so that everybody comes in on an equal basis – there are advantages in using an existing laboratory, incorporating the existing infrastructure and, even more important, using existing human resources. It is hard to set up big laboratories and make them work, and there are big advantages in basing new projects in existing centres of excellence with the necessary expertise. It certainly makes it easier for others to come in if the host nation or region contributes existing facilities and agrees to bear the long-term consequences at the end of the project. Second, collaborations work best when they are driven bottom-up by the scientists involved. Third, experience from the cohesion countries shows that drastic increases in R&D investment are not straightforward. The increase of R&D is limited not only by the scarcity of financial and human resources but also by organisational, institutional factors, like the administrative capacity. Contributions should be negotiated as early as possible in a project in order to involve everybody as real partners having a say in the design and orientation. De-ciding to do something in one country or region then inviting people in afterwards is not likely to work. It is essential either to involve people before project approval or to offer them added value if they come in later, at least if an open-door policy is adopted. Countries with fewer scientific resources or less scientific capacity need to be better integrated in the information flow within the scientific community in order to get access to the most advanced institutions. The increasing cost of journals and books limits the accessibility of scientific information in such countries. Fourth, to make a real partnership, the host region or country should offer others a proper voice in policy decisions, possibly out of proportion to their financial contributions, even if this seems rather generous to authorities. In considering reciprocal scientific collaboration, it is an illusion to seek what is sometimes called “detailed balance”. Fifth, it is very important from the very beginning to understand: what will be the “value added” if co-operation. The concept of European value added has been understood such a way that the value resulting from EU support for RTD activities should be additional to the value that would have resulted from RTD funded at regional and national levels by both public authorities and the private sector.

15. The concept that differences between the countries in size or in structure, matter as factors among the causes of success and failures of STI policies, has been challenged by some experts on the grounds that transnational corporations are the main sources of innovations, and they swallow most of the R&D capacities. Against these ideas, Michael Porter, the “father” of the concept of competitive advantages argued, that competitive advantage is created and sustained through a highly localised process. The national innovation system is the main structure for creating skills, developing and implementing STI policies. While it is evident, that the situation may be quite specific in most of the smaller countries, including the KNOGG participants, the most of the sources of success and failures in STI may be similar to the larger countries. They may be rooted in the system of microeconomics, in the market or in the production process or in macro-policies. For many decades, most of the empirical literature dealing with successes and failures has been dealing with the microeconomic factors and processes. They traced the direct effects of micro-decisions. The analysis of macro-policy decisions in STI, how they are shaped in the government structure, what specific interests are involved and how they influence the effectiveness in the national system of innovations should be stimulated.

16. The differences in size, development levels, R&D capabilities and policies demonstrate the diversity of the countries and influence also modelling. We do not intend to offer any optimal policy model in the KNOGG or in other countries. “Systemic models” may however help us to understand the special cases, factors and linkages influencing the innovation policies and reflect the ways in that innovation policy is devised and implemented.

On the basis of the main characteristics, goals and instruments of policies one may identify a few models for the governance of the national innovation system. The concrete goals of policies can be different in the framework of the models. One dimension of the strategies is related to the climbing of the countries on the ladder of the international technology system. The models of the STI policy process are of course reflecting the national policy system, which influences the role of different actors and the character of their interactions.

a) In the first model, a small country is depending mainly on the external sources of innovation. The aim is to promote the transfer, adaptation, diffusion and development of technologies and with their help moving in the direction of the more advanced countries. With these technologies, the country is taking advantage of innovations developed in other countries in the framework of its budgetary, skill and other constraints. The strategy used in this model is in fact an open policy that attracts transnational companies. It is necessary to create incentives to speed up investment, especially FDI. This is wise because new technology is usually embodied in new equipment, but also in new work practises imported by foreign investors – especially TNCs. There are a multiplicity of ways in which TNCs can enhance the innovation potential of the host country: they can make an important contribution to its research system through R&D spillovers; they can incubate high-tech spin-off companies; they can act as conduits for the transfer of codified and non-codified technology through human resource mobility and intensive-interaction with the indigenous sector; and they can stimulate the creation of networks of suppliers of high value-added products, components and services to supply foreign-owned industry. That kind of policy emphasises the business infrastructure (e.g. logistics), availability of educated and flexible labour force, and financial and fiscal incentives offered to investors. Examples: Ireland, the Netherlands, Hungary.

b) In this model, the country depends mainly on national sources of innovations and the government is playing a fundamental role in the STI process. The aim is to improve the absorptive capacities of the economy by creating a national innovation system, including advanced education system, high level research community and research laboratories, lots of R&D funding and intermediary institutions to bridge the gap between research and industry. Such a system promotes creation of original innovations, but at the same time it also improves the capacity to adopt and develop new technologies created elsewhere. The system can be risky. It requires long term political commitment. Example: Finland.

c) In this model, the market is playing a decisive role in the size, regress and patterns of STI. This is basically a Laissez faire. Believe the standard economics textbook model that the markets will take care of diffusion process. That, of course, may be the only alternative for a small country without sufficient resources to do anything. In this model there must be a powerful commitment on the part of the private firms in a number of exploratory areas of basic research.

There can be different competitive and institutional practices, formal and informal arrangements in the framework of these models. All the three models require considerable policy support and their success depends on the continuous flow of new information about science, innovations and the market conditions. Model one and two put greater pressure on governments, model 3 requires greeter efforts from the firms. The successful implementation of all the three models depends on the regular dialogue between governments, business, the academic world and labour. All of the three models require the participation in the global flow of knowledge in one way or another.

17. Rational decisions by the governments or other actors in the STI system are impossible without a well developed information base. For almost half a century efforts by different international organisations and national statistical offices have been made to develop national statistics and indicators on STI which facilitate the systematic measurement and international comparisons. A great number of indicators are used today around the world to measure different dimensions of science technology and innovations. There is a fast progress toward elaborating and accepting standard methodologies that aim at simultaneously establishing mutually compatible national and international systems of science and technology statistics and indicators. STI activities are diversified and are taking place in different settings and sectors even in the small countries. The innovation process is influenced by different domestic and international factors. Decisions on the different factors are also numerous. Some of these decisions are based on the subjective judgements of individuals who are representing the "wisdom" of different institutions. Other decisions may be based on anecdotal information or on the international "demonstration effect". They may be the outcome of well informed experts, or other individuals, representing different interests and claims. This type of information and knowledge is widely used in the often mentioned and increasingly popular foresight exercise, The role of factual information based on measurements and objective statistical surveys, on the status of the STI system and on its trends is growing also in STI decision-making. It may serve for measuring effectiveness, for checking anecdotal assertions, for building models which describe the operation of the different components of the STI system under various assumptions. *One of the areas, where factual information is particularly important is the benchmarking exercise which has become a popular instrument also for STI decision-makers on different levels of activities. The idea behind benchmarking is simple: find out what the best performers are doing and catch up, fast. It is a valuable idea for those who are exposed to international competition and are behind the standards of the best performers. The benchmarking exercise is a very rough evaluation of a country's performance as a whole and it has been argued that one cannot build a synthesis of the country's performance on the grounds of performance on individual indicators.* It is still evident that the performance on indicators such as the ones used in this benchmarking exercise reflect the results of different strategies of STI-policies of the KNOGG countries. It can be seen from the results that some other KNOGG countries have been more successful in creating efficient national innovation system as a strategy of being competitive. It

has become evident however also from WP2 and WP3 that the success of innovations, their rate of diffusion and the associated production and productivity gains depended not only on R&D but a wide variety of other influences which cannot be quantified. They include external factors, the systemic aspects of the social, technical and economic linkages, the policy process and its instruments, the form of work organisation, the appropriate interactions with the consumers and the related firms, sub-contractors, services etc. It is very important to look at the national system of innovations in a complex way.

18. Foresight is an other important multipurpose and increasingly popular instrument for policy makers. Its goals are of course not new. Governments, corporations, international organisations and academic groups used science and technology forcasting for the support of their long term goals. Foresight studies are aimed at the development of a common vision for the society, they identify future technologies and technological changes, they intend to guide national technology policies and offer "intelligence" for the different firms and institutions. They combine science vision, business vision and social vision on science and technology. The concrete goals and choices are of course influenced by the cultural, economic and institutional characteristics of the participants of the foresight exercise. According to the Report of the Irish team in KNOGG, the basic aim of Foresight exercise in Ireland for example is to assist the repositioning of industry higher up the economic value chain. This will be done by supporting selected technologies which are key to long term sectoral and national development. The Technology Foresight experience in different countries showed that important benefits emerge from the exercise, such as better communication, interaction and mutual understanding between scientific communities, industry and Government departments. The actual involvement in the intensive and interactive discussions about current problems and future scenarios and strategies has been of immense benefit to all participants, and will facilitate future co-operation and networking between them. Some experts underline however that foresight exercise should be approached with a prudent degree of scepticism. Nonetheless some experts consider it as a vitally important instrument of STI policies. *There are certain important conditions which are essential for the proper use of foresight: multidisciplinary approach, the participation of a wide range of knowledge "producers" and users and the appropriate understanding of factors which influence R&D and STI policies. It must be kept away from the influence of lobbies as much as possible.*

19. In the KNOGG project the social aspects of STI have not been dealt with in specific terms. Nevertheless they have been in the background of those processes which formed or influenced national policies. In the context of policies there are several problems which are directly related to the public's perception of science and technology. The influence of science and innovations on the society is probably the most widely discussed important issue. There are of course other questions. Why for example certain societies can innovate more easily and absorb innovations faster than others? The motivations to innovate depends to a great

extent on the direct and indirect influence of science and technology on the different layers of society, but also on the general intelligence and attitude of the population. This influences also the diffusion and role of knowledge. In the eyes of many people, science took the place of ultimate authority instead of (or besides) religion. Some started to think that science is omnipotent, anything can be solved by the means of it. It is important to note all these, because human society is still part of and determined by this process. During the 20th century science and technology became increasingly institutionalised, integrated into the policy making process. The process has become more contradictory after the 2nd World War Science and technology have a growing and more complex impact on human society, including the environment. The simultaneous of the positive and negative influence of science has created a rather ambiguous attitude toward science and innovations in the society.

20. It is evident from the above trends that the influence of science technology and innovations on people's lives is growing. While recent benefits to humanity are unparalleled in the history of the human species, in some instances the impact has been harmful or the long-term effects give causes for serious concerns. Within the general public, there is certain measure of mistrust and even fear of science and technology. Some is based on public experience, but much is the consequence of a significant communications gap between scientists, firms and the different groups and institutions of the society. Many reasons are advanced for these attitudes: public ignorance or misunderstanding of science, inaccurate or biased media coverage, uneven distribution of the costs and benefits of science among different sub-groups in society, lack of public control over the applications of S&T, and the inability of some scientists to communicate ideas in plain language. In part, the concern of the public stems from the belief that some individuals and communities will be the ones to suffer the indirect negative consequences of technical innovations introduced to benefit only a privileged minority. STI policies should take into account the social consequences of the technological applications or dissemination of the results of R&D, including the potential hazards.

There are a few main issue areas which must be taken into account in the future, also in the KNOGG countries. (a) The future of the individuals on the path toward the knowledge based society depends to a great extent on the opportunities of obtaining knowledge. Only a learning society can "climb" higher on the ladder of knowledge. (b) Equal opportunities must be offered by the society in obtaining knowledge. The gender aspects of these process are particularly important. (c) The example of the some of the KNOGG countries indicate that a social consensus is an important condition of success. This requires greater transparency in STI policies and effective participation of people in the democratic process. (d) There are also many ethical issues involved, from the honesty of science to the honouring of public interests in application and marketing (e) International co-operation should be also developed such a way, that the interests of the smaller and weaker partners will be taken into account. The process of co-operation must be more effective in promoting the catching up of the lagging behind countries.

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