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Towards a Science, Technology & Innovation Policy for the Republic of Armenia

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Foreword

Armenia on the Way to Inventing its National Future

World history has known few small and dynamic nations whose cultural heritage has equipped the region with intellectual capital sustainable enough to be considered an asset when inventing the future. Naturally these nations have to travel their own roads to overcome challenges posed by their national and international landscapes and distinctive features in order to engineer paths for their people to traverse on the journey towards well-being and quality of life. The people's labour is always the key to framing the future – the cornerstone of tangible and intangible infrastructure upon which prosperity can be built.

The required measures and underlying political solutions are always unique for a small nation, based on the ability to conform to the requirements of the surroundings and time in history. In justification of its decisions, each nation must consider its own distinctive traits, yet it is possible to learn from the choices made by others. In order to avoid failure, however, the models need to be adjusted to address the local concerns. Armenia's comprehension could be widened by examining the experiences of and development in small EU countries such as Finland, Denmark and Ireland during the past two decades.

The purpose of this report is to inspire and instigate change. The review deviates from typical committee reports –it is not a set of generic conclusions formulated as a compromise resulting from discussions between experts and decision makers. Instead, I have examined the current Armenian Science, Technology and Innovation (STI) situation and the development plans from various angles, focusing on identifying the measures needed to accomplish the desired change.

My mission to Armenia and my discussions with the more than a hundred dedicated contributors in the field of STI that I met in one-to-one exchanges and larger seminars impressed me greatly, helping me recognize Armenia's exceptional potential also in the field of STI.This approach was supported by the English reports, unfortunately small in number, reviewing Armenian science, education and economic development, as well as by the challenging alignments provided by the Government of the Republic of Armenia regarding the direction of the Science, Technology and Innovation Policy (STIP).

Based on my experience I am convinced that also political processes can be innovative. Finnish political decision making is often based on one-man-committees where the person in charge creates new, alternative and innovative solutions by leaning on expert opinions and public hearings. Therefore, I will in this report resort to a variety of material I have been involved in as an expert and decision maker in my various educational, scientific and innovation policy tasks and roles in the Finnish, EU as well as global arenas. The core of the background material that my insights draw from has been listed among the references.

The STI alignments of the Armenian Government open the door to the future adopted act: *Conception on Improvements in Science Sector in the Republic of Armenia* clearly indicates (see Appendix V, p. 78). Now it is time for determined decisions securing the challenging implementation processes.

I express my gratitude to all those involved for the many new and unique experiences in making this UNESCO mission happen. The most challenging part of the process of inventing the desired future is still to come – the stage is yours.

Markku Markkula

Director

Helsinki University of Technology

Preface

Science, Technology and Innovation (STI) are key components in achieving sustainable socio-economic development and are essential to maintaining and increasing innovation activity and economic growth. An effective Science, Technology and Innovation Policy (STIP) that promotes a coherent STI framework can help shape an environment that encourages social integration, facilitates globalization and enhances international cooperation. Today, more and more developing and transition countries, despite recent social, political and economic changes, are seeking to contribute to and benefit from scientific knowledge on an international scale. The Republic of Armenia, for one, is working to take an active role in establishing its place nationally and internationally by rethinking its STIP and decision making processes in an effort to pave the way towards an economically viable knowledge-based society.

The elaboration of this report was possible owing to the valuable contribution of Mr. Markku Markkula, a Finnish expert in the field of STIP and the support from Mr. E. Martinez, Senior Programme Specialist at the UNESCO Division for Science Policy and Sustainable Development. The Report aims to assist Armenia in identifying and developing policies that contribute to the increase of scientific knowledge and technological innovation. Its main objective is to enable Armenia to formulate STI policies and programmes that target investment in knowledge production and help to fuel long-term intellectual and economic development. It aspires to create an environment open to strengthening technological capabilities and innovation - and in turn increasing productivity, increasing global networking, achieving international benchmarking, raising the quality of scientific research, and establishing a stable social and economic environment. If the objectives of this report are to be accomplished, Armenia must support measures that stimulate technological and social innovation to improve its productivity and to maintain a thriving and competitive economy. Achieving this requires political commitment to formulate a clear action plan that is regularly monitored and evaluated to assess its strengths, weaknesses and opportunities.

This report is twofold. It begins with an overview of STI trends in today's globalized world, linking the international status of science to that of present-day Armenia by discussing what main components and priorities the Armenian Parliament should adopt and develop to respond to today's competitive STI environment. The report

then turns its attention to Finland (a country that has become a leading knowledge-based society over the past twenty years), focusing on its economic, technological, cultural and social developments since it began planning and implementing science policy measures that promote long-term, quality-based Research and Development (R&D) funding, high-quality education and investment in new businesses based on high-level expertise. Like Finland, by revitalizing the relationship between science and society through active and measured initiatives that work towards achieving sustainable development, social welfare and STI policy development, Armenia could not only work to improve quality of life and create a highly skilled workforce, but also secure sustainable economic growth by boosting its competitiveness on a national and international level.

The report concludes by outlining fourteen key development measures concerning STI to be undertaken in the near future. It proposes strategic developments such as the promotion of an effective National Innovation System (NIS), the consolidation of national science institutes to create a strong network of national institutes/centres of excellence, the improvement of social services such as higher education and lifelong learning, the development and upgrading of information and communication resources and the development and maintenance of a strong R&D infrastructure.

Given its mandate, UNESCO's main role is to encourage new thinking on policy development. It has a major role to play in the evolution of the Armenian STIP by initiating cooperation at regional and international levels, offering technical advice on STIP implementation; and facilitating capacity-building and networking opportunities. This report is hopefully only the beginning of a long partnership. Change is not always easy to achieve, yet with international commitment, political initiative and cooperation from various stakeholders, policy and decision makers we can work towards attaining the common goal of a viable knowledge-based economy.

I would like to take this opportunity to express our gratitude to Mr. Markku Markkula, the staff of the State Committee for Science (SCS), Mr. Hayk Asriyan from the Yerevan State University, and to all those who have made this Report possible.

Mustafa El Tayeb
Director
Division of Science Policy and
Sustainable Development
UNESCO, Natural Sciences Sector

List of Acronyms and Abbreviations

CANDLE	Center for the Advancement of Natural Discoveries using Light Emission
CoE	Centre of Excellence
CPD	Continuing Professional Development
CIS	Commonwealth of Independent States
EIT	European Institute of Technology
EPTA	European Parliamentary Technology Assessment Network
ERA	European Research Area
EUREKA	A pan-European network for market-oriented, industrial R&D
FP7	Seventh Framework Programme
ICT	Information and Communication Technology
KIBS	Knowledge-intensive Businesses and Service Companies
LIDAR	Laser Technology and Light Detection and Ranging Systems
NAS	National Academy of Sciences for the Republic of Armenia
NIS	National Innovation Systems
NFSAT	National Foundation of Science and Advanced Technologies
OECD	Organisation for Economic Cooperation and Development
R&D	Research and Development
RoA	Republic of Armenia
SCS	State Committee for Sciences
S&T	Science and Technology
STI	Science and Technology Indicators
TEKES	Finnish Funding Agency for Technology and Innovation
EU TEMPUS programme	Trans-European mobility scheme for university students
UNESCO	United Nations Educational, Scientific and Cultural Organization

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1. Introduction

This report attempts to describe and integrate the latest international STIP developments into the state-of-the-art of the Armenian science, education and economic life, which to a large extent is still looking for its national and global role and the route towards the future after the Soviet era. The level of Armenian research was among the highest in the Soviet Union, although targeted especially to military and space interests – this giving still a good starting point for the measures needed.

The Armenian STIP analysis has to be carried out in line with world-wide developments, where the breakthrough of new technologies has globalized science and especially the business processes. Instead of traditional in-house development work and contract-based company-to-company business operations, the entire economic life has, for years now, been building on effective clustering. In the cluster-based economy the traditional barriers between disciplines, organizations and operating sectors are broken down. Deep understanding and effective utilization of knowledge-intensive services and joint production processes are based on open and contractual cooperation between companies, universities and other research institutes. Today, even this change is not enough, and the paradigm shift to global value networking is already inevitable. In most of the industrialized countries the following factors are major obstacles and/or hindrances to the targeted change:

- Public sector tasks and operational processes change too slowly, and social institutions are not able to adapt their roles to changes in the environment;
- Although the importance of Research and Development (R&D) investments are strongly promoted by international expert reports, most national governments do not commit to long-term investments of this kind to the extent required;
- Work processes are not developed sufficiently to be based on effective knowledge management and Information and Communication Technology (ICT) is not deployed sufficiently to increase productivity.

International benchmarking shows that sustainable economic growth can only be founded on technological development and the continuous increase in the knowledge base. Scientific research has to be linked with effective technological development and innovation measures. The trends and developments in STI also explain, to a great extent, the differences in economic success between different countries.

The current situation along with its ICT-enabled intellectual opportunities provided by the global networking culture is making the Armenian science community face a scenario that differs totally from that of the early 1990s.

The needed development has been, to a certain extent and in some cases also in detail, recognized by the Armenian Government. Clear evidence of this can be seen by reviewing the government's decision in 2005 defining the following measures to implement the 2005-2010 program of formation of an innovation system in the Republic of Armenia (RoA):

- Submit draft RoA law on state support to innovation activities to the RoA Government
- Submit draft RoA Government decision on delegating authorized state body in the innovation sector to the RoA Government
- Submit draft RoA Government decree on setting innovation sector development priorities to the RoA Government
- Submit draft RoA Government decree on applying the innovation project financing procedure to the RoA Government
- Issue decree of the Head of the public administration body authorized by the RoA Government on approving the procedure of forming innovation project expert assessment, selection and review boards
- Create legal grounds for activities of venture funds
- Evaluate the scientific-technical and innovation potential that exists in Armenia and take inventory of technologies present in the various branches of the economy
- Organize standing exhibition of innovation packages in the Armenian Center for Scientific and Technical Information (State Non-Commercial Organization)
- Develop a project to study international experience (EU, Commonwealth of Independent States (CIS) and the USA) in innovation infrastructure creation and development management
- Carry out a development project of the Andron GHI Techno-Park CISC
- Create Scientific Innovation Center of Advanced Technologies within the Yerevan Physics Institute after A.I. Alikhanyan (State Non-Commercial-Organization)

- Create Information and Analysis Center within the Armenian Center for Scientific and Technical Information (State Non-Commercial-Organization)
- Create unified Information Network of Innovation Infrastructure within the Yerevan Physics Institute after A.I. Alikhanyan (State Non-Commercial-Organization)
- Create a center to support the commercialization of technologies
- Form scientific-educational complexes:
  a) Create legal bases for strengthening links between scientific organizations and the higher education system
  b) Organize Master's courses in scientific organizations
  c) Develop curriculum
- Develop a comprehensive plan for training innovation management cadre in science and technologies
- Improve legal framework for intellectual property protection and harmonize standardization and certification systems with international standards

The implementation of the various items included in this decision has progressed with variability. It has also been found problematic that even though the required measures have been identified, the resources allocated to the implementation do not suffice and the inter-dependencies between the diverse actions have either not been justified or marketed to the parties and actors involved. The motivation required by the change is not strong enough or has not reached all the participants. Subsequently this report needs to analyze the entire operating field in order to accentuate and prioritize such measures and core activities involved in the implementation that can help achieve the desired and, no doubt, imperative change.

2. Setting the Scene:
Armenian STI in an International Perspective

2.1. International Developments in Science and Research

The globalization of the economy and technology has accelerated cooperation and the removal of traditional boundaries. As a phenomenon, globalization is closely linked to network-building. Both are characterized by an aspiration for speed, flexibility and, through them, improved efficiency and effectiveness. Business tends to seek locations which offer the best production factors and markets. The internationalization stems, above all, from the business world, but public sector players, especially the ones within science and education, also have an active role.

The internationalization of science and research is progressing towards global networking. Internationalization, competition and cooperation improve quality, reduce overlapping knowledge production and help to pool existing resources and allocate them to important targets. Globalization not only challenges the economy, technology and research, it also affects countries and regions to their very core. Alongside industry and the economy, social structures are also changing and renewing. National decision making must be able to make the most of globalization by reinforcing the positive aspects of the trend. Speed, flexibility and high-standard knowledge are strategic assets for decision making.

One of the main lessons to be learned from the 1990s was that success in creating innovations is a key factor for thriving businesses and societies. One precondition for this is high-level technological and business know-how. Apart from technological innovations, this requires systematic input into producing social innovations geared to prevent societal and social development from diverging from economic and technological development.

The main challenge for economic and societal development, in conditions of growing global competition, is to be able to keep the country sufficiently attractive to business and jobs and as a living environment in general. Apart from the international challenges, there are always a number of domestic issues to be addressed. This is naturally the case for Armenia, too.

Measures must be taken to promote the utilization of technological and social innovations in business enterprises with a view to accelerating the renewal of traditional industries. Ministries will assume greater responsibility as funding authorities for strategic development and as users of social and administrative innovations. Research organizations and universities must be developed as active and dynamic cooperation partners for business and industry.

At the European level the *Lisbon Strategy* documented in 2000 set the target of making the EU the most competitive and dynamic knowledge-based economic area in the world by 2010. One of the targets of the *Lisbon Strategy* is to mobilize research and researcher training of the highest standard with a view to raising scientific and technological performance and, through it, the industrial and economic competitiveness of the continent to the world top. The internationalization of Science and Technology (S&T) has recently been most tangibly influenced by growing cooperation due to the enlargement of the EU, the European Research Area (ERA), the Seventh EU Framework Programme (FP7) and the establishment of the European Institute of Technology (EIT). At the same time, the EU member states seek to boost their national research activities by stepping up international cooperation. More collaboration, as well as healthy competition, is needed in European research. This is a critical question to be answered not only by the European development, but development more generally in the global sense.

Scientific research is characterized by global information and knowledge networks and globally operating science communities. The responsibility of the science community is to transmit this knowledge by means of publications and education to be assessed and benefited from by any interested parties. The missions of science include the need to expand understanding of what is theoretically possible and the potential impacts of technology.

The latest international developments increase significantly the pressure put on scientists. Simultaneously, the public and private sectors need to increase investments in R&D. The structures of scientific administration and science have been or will be reorganized in many countries. Development endeavours focused on innovations and their creation processes – social and administrative innovations, in particular – have introduced the integration of STI activities to the agenda of parliaments and governments, in order to leverage the national well-being policies and quality of life of the citizens. This signifies vast appropriations to be invested in the prioritized targets as well as legislative prerequisites to be established for long-term intellectual and economic development. A new objective for parliamentary activities is to affect the overall attitude and value development in society in a more accentuated way so that creativity, innovativeness and civilization can take a more highlighted role as the foundation of well-being.

Distinctive of all this development is the boundary-crossing integration of traditionally separately functioning industries, disciplines and in general diverse expert groups. This preconditions the redefinition of tasks as well as activities. It is essential to examine large entities and their internal subsystems, the interaction and inter-dependencies of diverse factors. Systems thinking is a growingly decisive success factor in R&D activities as well as in leadership and management.

Interdisciplinarity and multidisciplinarity together with systems thinking mean new challenges while simultaneously creating new opportunities to be tackled through the STI policies of small nations, in particular. These are the general international STI developments to be followed by Armenia, as well.

The Armenian Government's decision *Conception on Improvements in Science Sector in the Republic of Armenia* in July 2007 set several clear targets for action (see Appendix V, p. 78). The primary objective of improvements is the creation of knowledge-based economy and in this process strong state leadership is needed. Primary steps defined in more detail in the decision are as follows:

- Establish a united state science governing body
- Increase in science funding, clarify funding forms and mechanisms, enhance productivity of funding
- Enhance effectiveness of activity in scientific organizations
- Maintain focused and effective reproduction of scientific potential
- Modernize and create new infrastructures, material and technical base
- Introduce independent scientific expertise system
- Define science development priorities
- Integrate science and education
- Foster commercialization of scientific results and export to foreign market

This decision takes well into account the international trends and sets, not only clear targets but in addition, specified guidelines for the implementation. In most issues this UNESCO report is well in balance with those. However, this Report with its recommendations goes deeper to guide the implementation, as well as in some issues specifies a somewhat different route or routes in order to better reach the desired targets.

2.2. Effects of Globalization

Small countries having a knowledge-intensive tradition face enormous opportunities in tackling the challenges of their STIP. In the case of Armenia, much can be learnt through benchmarking the recent developments in small countries which have undergone a transition to become leading knowledge-based societies within the last twenty years. In this chapter, the experiences of Finland are described and applied to the use of the STIP decision making process in Armenia.

The Government of Finland described globalization in its *Futures Report* to the Parliament in 1997 the following way: "All countries belong to a worldwide network of dependencies and interactions. In the evolution of this network - globalization - the economic dimension, i.e. the system of worldwide production, trade and financing, has become increasingly important, particularly since the end of the Cold War: International trade has become liberalized and has expanded rapidly. The role of direct foreign investment in the global industrial structural change has been decisive since the mid-1980s. The deregulation of international financial markets has increased the effect of speculative capital on national economies, beyond the control of political decision-making."

With global change, the distinction between national *internal* issues and international *external* issues has become blurred. The boundary between *political* and *economic* has also shifted. This has been an on-going trend from the early 1990s.

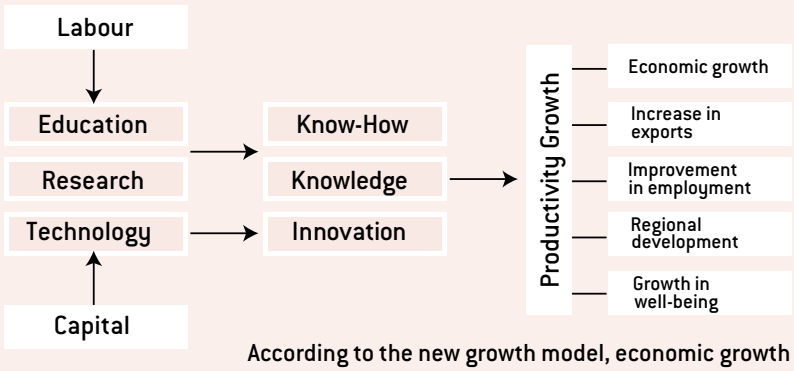
During periods of rapid change, discontinuity is emphasized in public debate. However, in assessing future trends in the long-term, historical continuity is often more significant. In addition to geographical location, historical changes, in the case of Armenia, in demographic trends, the environment, social structures and the deep structures of culture, i.e. national mentalities, are important in shaping the future.

In a rapidly shifting economy, company and sector structures are in continuous flux. If the economy does not generate sufficient organizational, social and technological innovations, the economy will not reach the needed dynamics. In recent years, company organizations have seen unprecedented upheavals, too. Companies have undergone enormous changes: centralized, devolved, incorporated departments, integrated, merged and pruned marginal functions. And now, totally new business cultures to operate within global value networks are emerging.

An efficient use of technology leading to permanent improvements in increasing competitiveness, as well as in welfare in society, requires changes in organizations and institutions, training and education, and translation of technological expertise into commercial and economic success.

In recent years, the global emphasis has been placed on industrial and technology policy, and to a certain extent, in countries like Armenia, this still needs to be the case. The essential content of the new policy is to link heavy STI investments to industrial policy. This means, among others, setting up incentives for specialized knowledge-intensive business services and other production factors needed in the future, promoting competition, and generally providing advantages of location to internationally competitive companies. According to the new growth model, economic growth is rooted in education, research and technology. Special attention needs to be put on innovation and productivity. Political action is needed to achieve what the markets cannot. In this development, policy makers must set their priorities.

Figure 1: Economic Growth Model: Know-How, Knowledge & Innovation



According to the new growth model, economic growth is rooted in education, research and technology.

Source: Markkula, M. TKK Helsinki University of Technology, 2007

Recent economic and societal development has essentially been based on the development of high technology, its effective utilization and determined increases in exports. This has resulted in a significant improvement of Finland's position in international competition. According to international comparisons, Finland, recuperating from the recession of the 1990s, has succeeded in combining extensive production and economic utilization of knowledge and know-how with other aims, such as the promotion of welfare and sustainable development.

3. Inventing the Future:
Benchmarking Finland

3.1. The Future Lies in Knowledge and Competence

In terms of international comparison, Finland has for the last ten years been in the forefront of information society development. Finland has made substantial investments in education, training, research and development. Information and communications technology products have significantly contributed to the growth of Finnish exports. At the same time, the challenges have been and are the ageing of the population, unemployment and the hectic pace of working life, together with shortages of competent workers in some fields.

The *European Growth and Jobs Monitor* is an annual survey of Europe's economic and social progress. Small countries rank high in this benchmarking. In 2007, Finland and Ireland made substantial improvements in their score, over performing the previous year's winners Denmark and Sweden (see **Table 1** below). It is striking that some small countries are turning in exemplary performance as top-rankers while, in contrast, the EU heavyweights like France and Italy have some serious weaknesses to address. And Germany, the biggest European economy, only managed in the course of last year to edge its way up from the bottom third of the list to the middle ranking – a welcome development, but hardly one which should encourage Germans to drop their ongoing effort to reform and modernize their country.

Table 1: European Growth and Jobs Monitor, 2008

Current Scoring (2007 Q3)								
Current Ranking overall	Country	Overall Score	Economic Growth	Labour Productivity	Employement Ratio	Employment by Tertiary Education Level	Investment Activity (Equipment)	Public Finance
1	Finland	1.69	1.53	3.05	1.05	1.17	0.71	2.64
2	Ireland	1.44	1.88	2.13	1.03	0.99	0.60	2.04
3	Denmark	1.41	0.73	1.73	1.08	0.91	1.29	2.72

Source: European Growth and Jobs Monitor, 2008: Indicators for Success in the Knowledge Economy

To understand the secrets behind this and other international competitiveness rankings where Finland has been among the first ones, we will review several national reports analyzing STIP. Finland has succeeded in combining the application of technologies, welfare, sustainable development and continuous renewal.

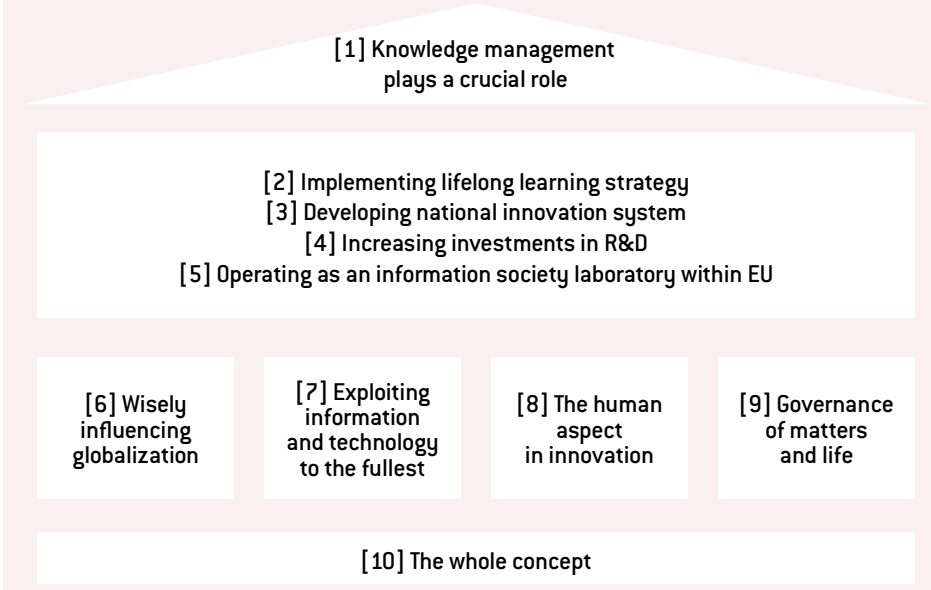
Finland has a good base for further development as a leading innovative environment, which generates a multiplier impact and creates the necessary prerequisites for the international success of industry and society, along with growth and sustainable development. By developing technologies, it is possible to find solutions to the basic needs of society and industry. The development of technology helps to maintain all current competitive advantages and to create new ones in many new fields, which further improves welfare. The development of high technology applications is further boosted by the introduction of new cooperation models. Technological applications are aimed at improving the quality of life.

Finland is one of the most competitive business and research environments globally. The country also has favourable premises to continue development as the top innovation environment in the future. It has profound effects on global competitiveness, steady growth and sustainable development in Finland and also has a broader supporting effect. In international comparisons, Finland is at the cutting edge in terms of competitiveness. Finland's assets continue to be in the innovation environment, although the improved economic situation has also contributed to Finland's rise to the top. Today, Finland is recognized as one of the high-tech centers of the world – a fact which provides unique internationalization opportunities for Finnish companies and attracts direct investments to Finland. Tekes, the Finish Funding Agency for Technology and Innovation (formerly the National Technology Agency and originally, when established twenty-five years ago, the Technology Development Centre), is supporting the growth of businesses through technology development and it also helps the growth of welfare in line with sustainable development.

The formulation of the technology strategy has been based on a three-dimensional approach: [i] studying of industrial clusters, [ii] certain cross-technological technologies and [iii] important ways of working. Global trends and the needs in clusters have shown the way, and cross-technological effects and opportunities have also been taken into consideration.

Finland has benefited from smooth interaction and mutual understanding between the public and private sectors in regards to the necessary investments. As the industry has rapidly moved toward a technology-intensive direction, public educational and research investments must follow the requirements. The fact that public research and development investments have been lagging behind the objectives set by the Council of Science and Technologies in the past few years has aroused concern. This may weaken especially the development of the strategic knowledge and competence base.

Figure 2: The Finnish Road to Success: ICT is the Driver of Charge



The following list defines in brief the unique success factors of each element in this Finnish model.

[1] Development and use of personal and organizational knowledge management toolbox.

[2] E-learning is implemented with special focus of the needs of changes in learning and working culture.

[3] Linking innovations and productivity and stressing the importance of commercialization.

[4] R&D and development of work processes are linked together.

[5] The role of forerunner means the effectiveness in developing concepts based on parallels processes. It means being an effective user of knowledge created globally.

[6] Profitable "business" is more and more based on value network management, where different actors operate on mutual dependencies based on shared interests and trust.

[7] Knowledge building and knowledge creation are based on what the others have already in use.

[8] Not only technological innovations, but also social, cultural and administrative innovations.

[9] Motivation and tools for personal and organizational competence development and better quality of life.

[10] Managing this knowledge ecosystem through effective systems thinking.

All the elements in this Finnish model are greatly influenced by ICTs
Source: Markkula, M. TKK–Helsinki University of Technology, 2007

The competence of each citizen becomes important. Concern about competent experts in the future requires the development of the educational system in line with social change and the principle of lifelong learning. Finland will need top specialists in various fields in the future, and also the creative people who can combine the various fields. Challenges become more and more cross-technological, which gives a key role to cooperational skills in the society of the future. Finland will also need to utilize the different resources and approaches of women and men better than before. Individual responsibility for continuous development will be further emphasized. To maintain well-being and an enthusiasm to work, it is essential to pay attention to the reconciliation of work and leisure time, and work and family life as well as to benefit from flexibility.

Business operations benefit the networks in an innovative way. Value networks enable and necessitate the renewal of business models and earning logics. The integration of services into the business entity often creates important new opportunities. Everyone does not need to know everything in a networked operational culture.

3.2. Setting Priorities for STI and Industrial Policy

Armenia has the advantage of benefiting from experiences gained worldwide from STIP solutions. The situation Armenia is facing in their STIP today bears a great number of similarities with the situation Finland faced in the mid-1990s. The similarities are, in particular, related to the question: does the government have the courage to commit to long-term investments that it understands as crucial for the STIP. No doubt, this decision will be found difficult as at the same time the pressure of investing the funds on consumption investments immediately affecting the citizens is huge. Naturally many issues – on the national as well as international levels – are unique, but still it is possible to learn from the analytical conclusions drawn and their impacts on successful development. Therefore a brief summary of the decisions made then and the subsequent conclusions will be presented below.

In 1996, the Government of Finland decided to allocate new investments worth about 500 million Euros to R&D. The purpose of this additional appropriation, disbursed between 1997 and 1999, was to enhance the operation of the NIS to the benefit of the economy, the business environment and job creation alike. An independent external expert group evaluated the outcomes of this investment. In brief, in their report *Assessment of the Additional Appropriation for Research* (Prihti et al., 2000), they stated that "the results were a success, but continually changing conditions make future STI policy face new requirements." With this respect, they summarized the following priority areas for action:

(a) Policymakers Should Continue to Set Ambitious Aims for Research Funding

International competition has become a learning race. Like Finland, many other countries have made heavy investments in the development of research and

education. Finland should continue this course of action chosen, and maintain its high level of research funding. Setting up a new additional appropriation program should be considered, with the aim of complementing existing measures and redressing the deficiencies that are currently evident in the Finnish innovation system.

(b) The Conditions for Basic Research Should be Strengthened

Continuous improvement in the quantity and quality of basic research must be secured. Basic research contributes to producing the basis for applied research and to increasing the number of highly skilled personnel. Financing centres of excellence can be used to accelerate the progress of promising sectors. Networking in Finland and abroad, as well as cooperation with business enterprises, should be strongly encouraged. Despite the generally high levels of industry-science cooperation, there is still room for improvement, notably in biosciences.

(c) The Cluster Approach Should be Improved and Extended

Knowledge of cooperation between different sectors, gained from cluster programs, should be developed and extended to new areas. However, the existing clusters need to be more focused on.

(d) The New and the Old Economies Should be Integrated

To accelerate the integration of the new and the old economies, small and medium-sized enterprises operating in conventional sectors should be actively encouraged to take up new technology. An accelerated schedule calls for a special program.

(e) More Focus Should be Placed on Innovation

In future technology programs, the following aspects should be further underlined:

- Improvement of efficiency of know-how transfer from abroad to Finland
- Development of cultural know-how and managerial skills to complement technological competence
- Development of pre-seed and seed financing
- A customer and marketing-oriented approach
- Greater commercial professionalism, especially in small and medium-sized enterprises
- Creation of a special form of support for commercialisation of products since, due to the small size of the domestic market, a small company must start to operate internationally at a very early stage

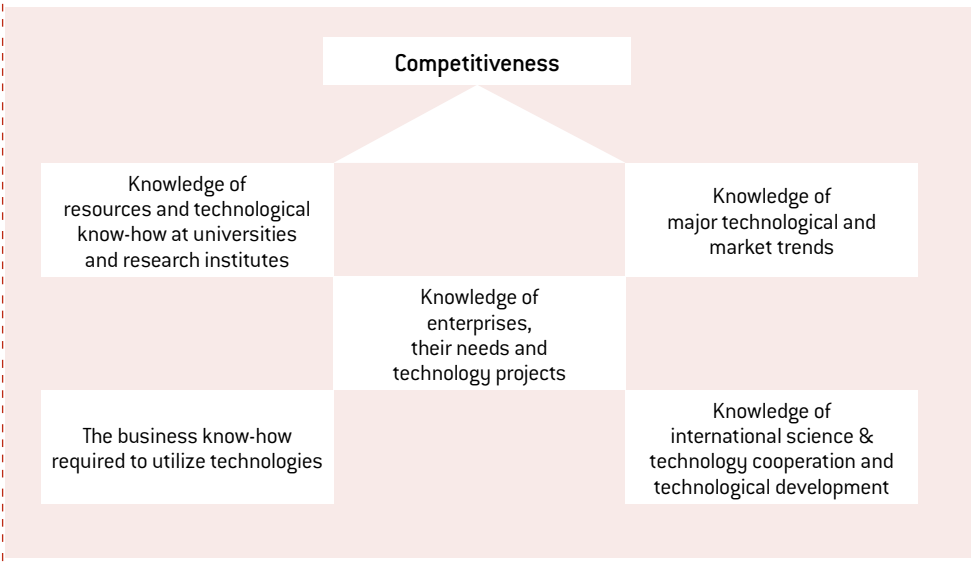
(f) Future Work Force Competencies Should be Developed

Future success will rest upon skilled people. Therefore, a permanent aim should be to improve educational opportunities for both the younger and the older population.

- The challenging new task for polytechnics relates to the integration of the new and the old economies and skills technology
- More flexible switching from one subject over to another would improve the opportunities for highly educated personnel to move into areas where demand is growing rapidly
- The universities' capacity for educating students from abroad should be improved considerably

All six items of this list of recommendations are essential for the Armenia of today. They show the broad spectrum of activities needed in securing the foundation for creating welfare through an effective STIP. International benchmarking provides clear evidence on the need to focus particularly on increasing the role of companies in national technology and innovation operations. **Figure 3** shows the importance of interaction of different actors and their activities in building the route towards competiveness.

Figure 3: Companies and Technology at the Core of STIP



Source: Markkula, M. TKK Helsinki University of Technology, 2007

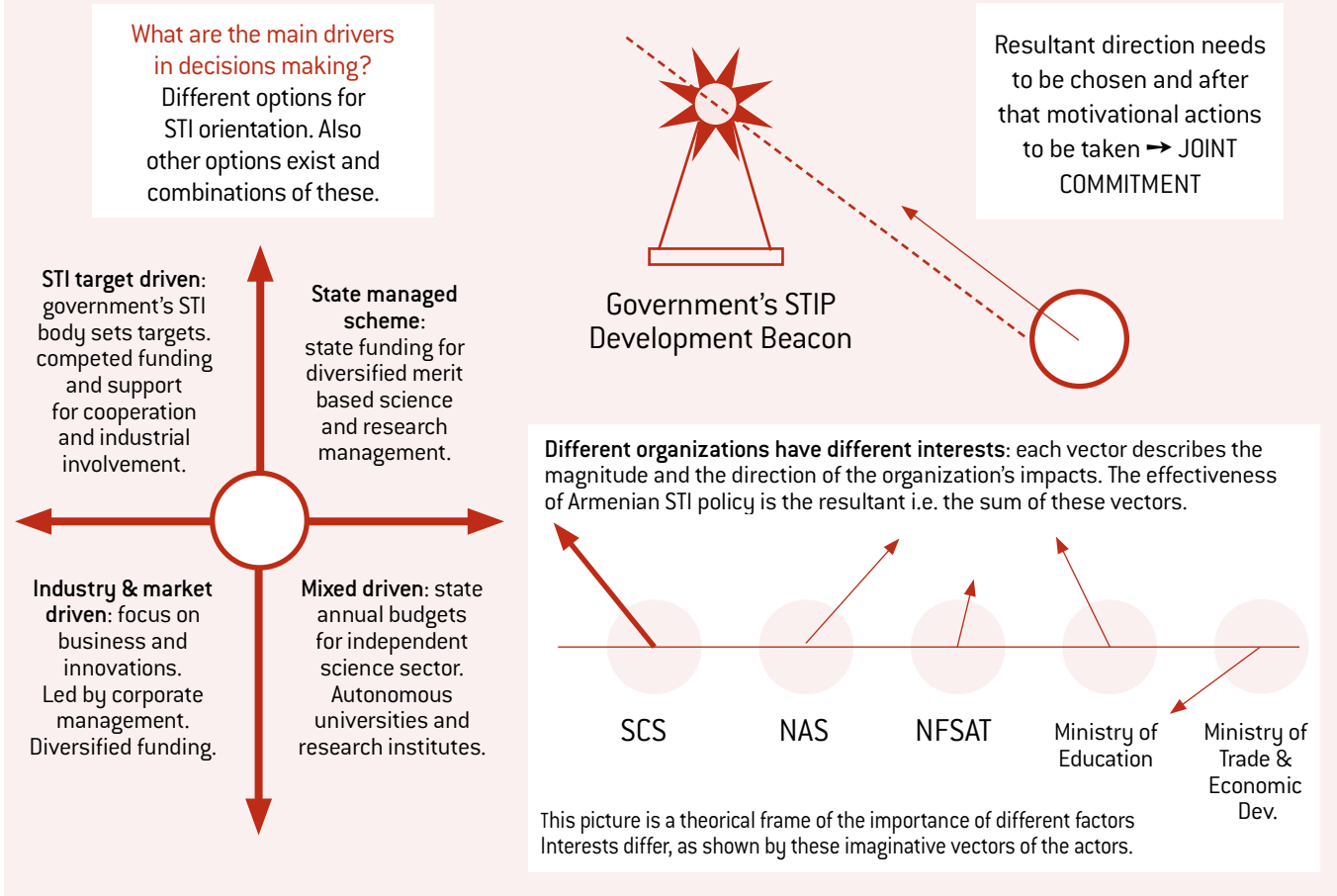
Due to the great structural and content-related need for change, consideration should be given to setting up a pilot program to ensure that the necessary development will materialize. Furthermore, basic funding for universities must be increased and targeted to meet the new demands of the STIP. The lifelong education of today's work force should be further enhanced by trying out new ideas and preparing new pilot programs. Good examples already exist internationally. It is important that the government guarantees sufficient resources for continuing education to ensure the availability of a highly skilled work force and to prevent labour market exclusion. The actions can and should be planned with the best European university-based continuing education providers and lifelong learning system developers.

3.3. National Commitment: the Key to Success

Armenia must not allow its outstanding historical civilization and science to erode. Now that the preconditions of international networking are in place, it is essential to make the required decisions and commit to a persistent STIP program which will help implement a significant leveraging of funding as well as the needed structural and functional reforms. This change needs to be backed up by strong and sustainable national commitment.

Inviting the commitment of all the significant stakeholders to accept common goals and to act in conformity with common values is always a challenging process. Especially in extensive economic transitions like the one being experienced in Armenia, cooperation should involve actors from diverse backgrounds, ranging from corporate heads to professors; and from young entrepreneurs to focused scientists. This increases the challenges on decision making and requires determinedness, expertise, interpersonal skills and wise leadership. The motivation of the diverse actors is decisive. In light of the objectives set by the Armenian Government, the integration of the actor groups' interests will not be easy.

However, major decisions must be made without delay and with determination, as time is now more than ripe for action. Armenia's many-faceted science community has for too long remained in anticipation, without sufficient resources to meet even its basic needs. At the same time the interest in the field especially among the young has decreased. Each actor has had to focus its operations to concentrate more on its own interests while constantly cutting costs. Now it is time for cooperation and integration. This starting point is illustrated in **Figure 4**, where the direction and magnitude of the vectors depicting the interests of the various actors have been described randomly. Everyone acquainted with Armenia's STI activities can, however, easily recognize how the interests depicted differ or can differ when reflecting on the actors' own points of departure.



Source: Markkula, M. TKK University of Excellence in Adult Education, 2007–2009

Figure 4: Importance of Joint Commitment

There is no longer point in wasting time on analyzing the current status and interests of the various actors, but instead effort should be put on taking action to build a common future. Of special importance are the profound processes, the most important of which are depicted in the recommendations section of this report.

When instigating the required change processes one should not focus too strongly on planning future steps in detail. The chances of accomplishing significant outcomes are, no doubt, realistic. What is needed now is start-up funding for various new operations, as is also the direction and commitment. It is time to move from traditional administration towards advanced leadership and effective STIP management processes. International benchmarking in the area of STI integrated into human-centric ICT development needs to be engaged. This is demonstrated in this report by the descriptions of lessons learned through the Finnish and other international knowledge society policies.

Sufficient basic funding together with effective decision making and implementation structures are only prerequisites for an effective NIS. As an example, with a view to promoting more favourable conditions for innovation, the resources of the Academy of Finland and Tekes have steadily been increased in addition to structural changes which have been made regularly every few years. This has enabled them to take care of the development of new growth fields, research-based innovations and innovation environments. The effectiveness, however, derives more from the strong national commitment of all major actors to develop measures, STI activities themselves and the required long-term policies.

Figure 5: Finnish National Technology Strategy – Lessons Learned

[1] Why networking?
- It combines the best possible knowledge and competence
- Cross-technological cooperation and internationalization require networking

[2] Why cross-technological cooperation?
- It helps to find new competitive advantages
- It makes the industrial structure more versatile

[3] Why long-term commitment?
- It creates the basis for R&D
- It brings forth competence and experts

[4] Why innovativeness?
- It speeds up the commercialization of technologies
- It renews the industrial structure and competence base

[5] Why productivity?
- It is the precondition for competitiveness and welfare
- The sound application of technologies increases productivity

Source: Markkula, M. TKK University of Excellence in Adult Education, 2007–2009

The international benchmarking of developments from the mid-1990s has taught, above all, that success in creating innovations is a key asset for both business enterprises and societies. That there is open, constantly growing international competition for innovations and their producers. Speed and flexibility, together with high-standard knowledge and know-how, are a strategic advantage in this competition. Countries which have these assets have an edge on others in seizing the opening opportunities. At present Finland is among these countries.

National commitment towards education and learning, as well as high-level investments in R&D, have been a driver of positive development. Finland's development, in recent decades, shows that one key success factor has been the wide-spread national attitude and will to develop technologically. People consider this change to be a positive one. An important cornerstone of this attitude has been, and is, that social welfare is an essential target of investments in technological R&D. This is clearly stated in the national vision for Finnish information society development, which was defined in 1998: "Finnish society develops and utilizes the opportunities inherent in the information society to improve the quality of life, knowledge, international competitiveness and interaction in an exemplary, versatile and sustainable way." (Ministry of Education Finland, 1999).

The information society was defined: "In the information society, knowledge is the basis of education and culture and constitutes the most important production factor. Information and Communications Technology (ICT) promotes interaction and exchange of information between individuals, business enterprises, and other organizations, as well as the provision of services and access to them." (Ministry of Education Finland, 1999).

Since then, technology has matured as a facilitator of broad societal changes, the realization of which requires the reform of structures and operating models in conjunction with the implementation of technology.

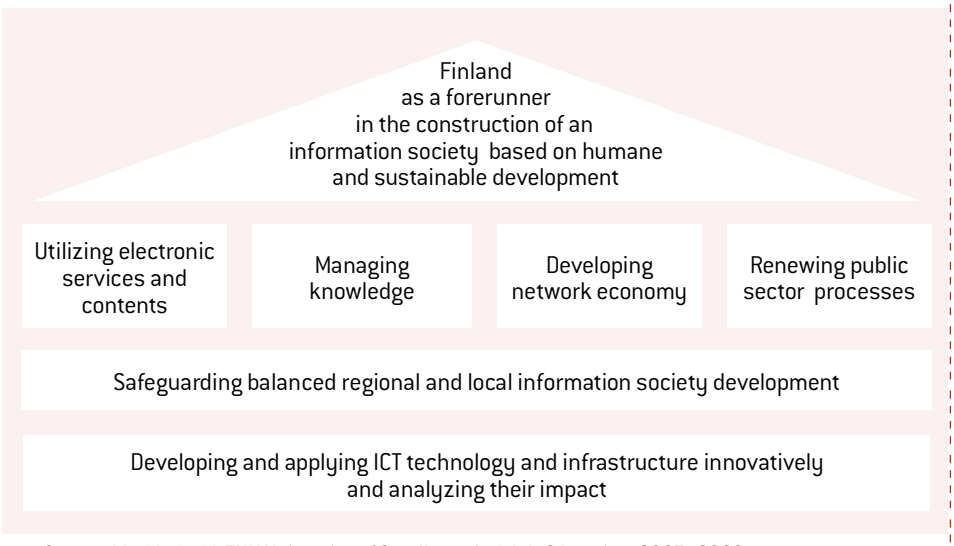
Today knowledge is an even more important resource in our society, which, with the help of technology, can be utilized more effectively than ever before. The strategic priority has shifted from being a society that utilizes ICT, to one that generates knowledge-based growth enabled by ICT. The broad utilization of information provides Finland with the opportunity to function as a global reformer and develop new skills and business. This will require seamless cooperation between different stakeholders and the development of ideas into products and services.

The goal in the Finnish information society development was defined to:

- Increase welfare, and create jobs and income
- Provide equal opportunities for the acquisition and management of information, and for the development of knowledge
- Improve conditions for entrepreneurship and the quality of working life, and promote competitiveness
- Increase opportunities for human interaction and cooperation
- Strengthen democracy and opportunities for social influence
- Improve security and the individual's data protection and status as a consumer
- Develop services and cultural provision and increase international interaction
- Boost Finland's attractiveness as a location for innovative enterprises
- Alleviate inequality between regions
- Support the objectives of sustainable development

With respect to Armenia, the challenge, among others, is to plan the continuum of processes which would enable the motivated involvement of parties with extremely varying interests in both individual endeavours and NIS development activities on a more general level. STI professions must be made more attractive. This objective could be pursued by implementing an extensive and open information society program. Various interests need to be secured for the diverse citizen groups.

Figure 6: Vision Finland as a Forerunner: Joint National Commitment in 1998



Source: Markkula, M. TKK University of Excellence in Adult Education, 2007–2009

4. Key Actors:
National Innovation Systems

4.1. Scientific Research and Science Policy

During the 1990s, Science and National Innovation Systems (NIS) were placed under growing economic and social pressures and as a result of that have undergone extensive changes in all OECD countries. The hard core of the science system consists of universities and research institutes being in most cases integrated into their structures and processes. NIS is nonetheless a much larger system comprising of companies with their R&D operations as well as government organizations responsible for the STIP.

In NIS, science needs to have an autonomous role in its internal operations, yet guided through the basic and competitive funding the decisions of which are to be based on international independent evaluation.

Through the changes in the global economic system, universities and scientific research have strengthened their roles in all sectors of political life with special focus on new partnership needs and opportunities in regional and global arenas. Efficiency, productivity, quality and assessment are the requirements placed upon science and research, close to the same extent they have been the drivers of change in industry and public sector policies. However, the role of science has to be seen mainly as the maintainer and developer of knowledge-creation processes that work to secure the factors of long-term societal development.

Similarly, this means that not just the impacts of science but also the efficiency of R&D processes are under much closer scrutiny than in the past. Reviewing the science policy in small industrialized countries, the following changes which are of important value when considering the needed science policy decisions in Armenia, can clearly be detected:

- The value of scientific research is increasingly measured throughout the value chains of innovative products and services
- Science is integrated into industrial disciplines and public sector services
- R&D funding is increased and focused on the priorities set based on the societal decision processes and international evaluation

- Inside science, multidisciplinarity and interdisciplinarity are seen to have growing general importance for economic development, and in this respect regarded especially as the foundation for innovation
- New components and concepts, such as science parks, incubators, centers of expertise, centers of excellence, technology programs, cluster programs and different funding bodies, are created to operate within the NIS to secure both the effective and wide use of knowledge and the healthy competition
- Incentives for creating new strategic partnerships are used to encourage knowledge sharing and collaboration
- The role of companies in R&D is increasing with strong development of public-private partnerships
- Post-graduate education and professional development of skills and competencies of researchers and other key knowledge workers are an integrated part of the science policy

To function properly, the science system needs to be supported by adequate and properly allocated funding, which has not been the case in Armenia. Small countries are not in a position to compete with large countries in terms of absolute volume of their research funding or research outputs. However, as the case of Finland clearly indicates, the committed and long-term increase in R&D funding integrated into the development of NIS with careful allocations of research funding and systemic change operations throughout the whole system can have a strong impact on the economic and social outcomes of nations. The cornerstone in this kind of development in Armenia can be the strong role of the State Committee for Science (SCS). In planning its operational structures and processes a useful benchmarking for SCS is the twenty-five year history of Tekes through its establishment as the technology development centre, then further developed into the national technology agency and presently operating as the funding agency for technology and innovation. The roles and responsibilities of Tekes in parallel with the ones of the Academy of Finland have undergone an extensive development to assist R&D carried out by universities, other research institutes and companies. Their roles have been instrumental in allocating state R&D funding and in operationalizing international cooperation, as well as in the development of processes in basic and applied research and throughout the whole NIS.

4.2. Towards a Knowledge Society

The ongoing change means a transition from an industrial to a knowledge society, and as a result, education is fortifying its role from an ancillary service to a leading force of economic and social development. Traditionally the three main aims of education were to build disciplined individuals, competent workers and respectful citizens. This way

was perfectly suitable to the classic industrial society which reserved responsibility, creativity and political initiative to smoothly enlarging elites. What sort of individuals, workers and citizens are needed in the knowledge society? Several answers can be given to this question, but a large consensus exists, not only among educationalists, on the fact that autonomous individuals, entrepreneurial and creative workers, responsive and socially active citizens are preferable to the versions considered more popular in the industrial society. Innovation and creativity are now valued as keys to successful economic development, the real wealth of nations of the 21st century.

There is not a unique standard knowledge society model. However, based on several evaluation studies the following factors seem to be fundamental for the knowledge-based economy:

- Creativity and innovativeness are the driving forces
- Effective networking is a way of life in creating a shared knowledge reality among both individuals and organizations
- Increasing intellectual capital is the most important value base factor of work organizations
- Knowledge management and encouraging systematic lifelong learning are bases for building a concept of a learning organization
- The future of economic success is more often built on the NIS with special emphasis on a well-targeted regional innovation policy
- Increasing the investments in research and development play a crucial role in the governmental policy

In the new kind of knowledge economy, the attitude towards knowledge differs from what it was previously. Knowledge is capital, which need not and must not be saved. Knowledge is like joy: it increases when it is shared and is replenished only when squandered. In the past, knowledge was power, which could be "kept under the mattress" or used only to achieve one's own purposes and dominate others. Power belonged to the few, and the more limited that oligarchy was, the more power they had. Advocates of the ideology of knowledge management argue that thinking in relation to knowledge must be altered in such a way that people understand that the distribution and sharing of knowledge is power – a power that belongs to us all. Corporate executives and consultants emphasize that active networking is a precondition for international success.

Figure 7: Innovation – Profitable Investment for the Future

Investments	Results	Direct Effects	Impact on National Economy and Society
• R&D investments • Knowledge Creation • Knowledge Transfer	• Competence • New knowledge • New business models • Networking • Innovations: products and services, methods and processes, organizational innovations	• Start-ups, new business areas and services • Growth and globalization of companies • Productivity	• Renewing business structures • Affluence • Regional vitality • Employment • Environment and health • Security and safety • Social well-being

Based on Tekes the Finish Funding Agency for Technology and Innovation
Source: Markkula, M. TKK University of Excellence in Adult Education

According to The New Club of Paris[1] the characteristics of the emerging knowledge economy can be described as follows: A major challenge from the future changes is that our economy is increasingly transforming into an *intangible* economy which is described as a "knowledge based economy". Indicators of this development initially are:

- The new relation between material (e.g. manufacturing) and nonmaterial (e.g. services) resources
- The sharing of commonly available knowledge
- The realization that global competition can lead to rapid relocation of economic activities such as software, media creation, healthcare as well as *mind-intensive* industries
- The radical change in work structure leading to lifelong learning, adaptation and flexibility
- The increasing *knowledge divide* within societies as well as among nations on a global scale

1. The New Club of Paris is an association of scientists and intellect entrepreneurs dedicated to research and the promotion of the idea of supporting the transformation of our society and economy into a knowledge society and knowledge economy. www. the-new-club-of-paris.org

The move towards the knowledge society and knowledge economy affects both the micro- and macro-economic dimensions. This change, which is deeper than often stated, does not protect *traditional* industries. The knowledge economy has an impact on the value creation process, fundamentally altering the organization of work, creating new forms of borderless cooperation and intercultural exchange.

One of the important aims in knowledge work is to create new knowledge rather than merely to distribute or store what already exists. People's subjective interpretations are more and more important in knowledge work.

Information technology and information networks have made learning and knowledge independent of the constraints of time and place. Information is created and distributed globally online via social software. With respect to organizational learning, the main focus needs to be on knowledge creation theories and the preconditions for a learning organization. Technology impacts both individual and community learning by providing tools and support for the creation and distribution of knowledge.

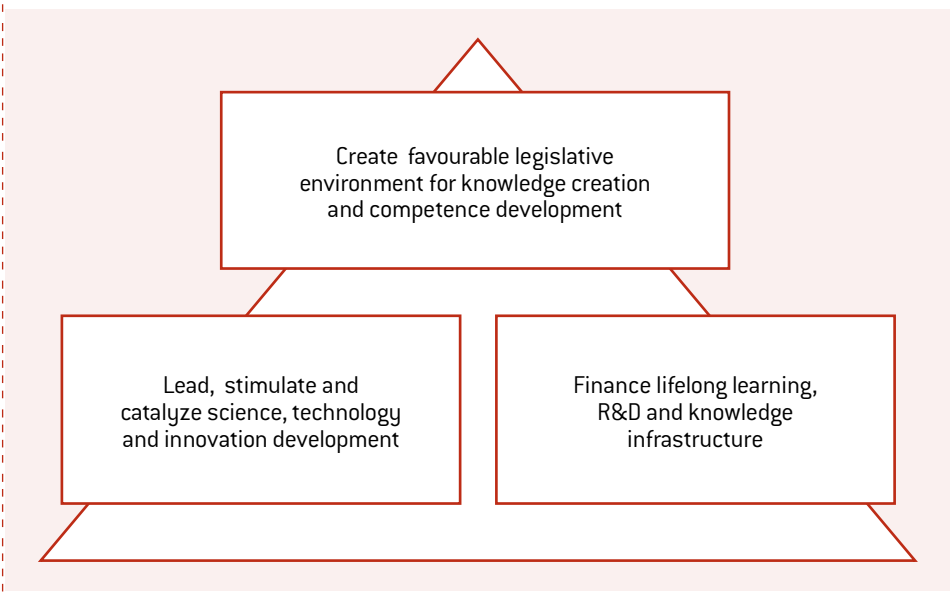
The major success factors in NIS are the political commitment to increase R&D funding together with the well functioning financial process of prioritizing the activities and focus areas. Armenia needs like every nation to find its own way. The profitability of additional investments is essentially dependent on how well the whole innovation system functions. A balance has to be found between basic research, applied research, product development, technology development and training. The innovation system needs to be developed so as to improve its quality, efficiency and relevance. This, however, is not enough. The close cooperation and interaction between the innovation system and other policy areas is also essential.

4.3. UNESCO International Round Table: Science, Technology and Innovation Policy: Parliamentary Perspective

In 2003, UNESCO organized, in collaboration with the Parliament of Finland and ISESCO, a special international parliamentary Round Table to tackle the issues of STI development. The key message coming from the seminar was to encourage parliaments to take a proactive role in developing science, technology and innovation policy to increase the quality of life and human welfare.

There are a number of key analytical lessons that can be learned from the national parliamentary experiences. These lessons can be sources of reflection and inspiration for other countries and regions of the world. The Round Table engaged in in-depth discussions about the major fundamental factors impacting national and global STI policies.

Figure 8: Role of Parliaments in National Innovation Policy



Source: Markkula, M. TKK University of Excellence in Adult Education

Prof. Reijo Vihko, the Director General of the Academy of Finland, addressed the Round Table with the following statements, which are of special importance for small countries in defining their strategic steps towards an effective STIP.

The management and development of the research system as a whole requires close and flexible cooperation between the key actors in the field. The future is always uncertain. It is uncertain globally and to the big countries, and it is definitely no less uncertain to small countries. The research system cannot be developed merely on the basis of challenges presented to us today. The system must also be prepared to answer questions that researchers or society cannot even ask today. The outcome will be to secure the renewability and diversity of research.

There is no ready-made formula or patent for success. Each country pursues its own visions from its own starting points. We cannot today anticipate and we do not know all the challenges that will be posed to us tomorrow. It is, however, most important that we do our best to promote the most essential targets. Key global challenges (nutrition, the environment, energy, clean water, health) concern developing countries most deeply. These global problems also pose urgent challenges to science, both nationally and internationally. Science alone cannot solve the problems of the world but it can take the lead in alleviating and resolving several of these problems.

The role and the challenges of research are basically the same in all societies. For developing countries it is most necessary to be an active partner in international scientific collaboration. There is no separate science for developed countries and for developing countries. All benefit from high-level scientific research. Science is the best instrument for building economic, social and cultural well-being.

As a result of the discussions, the Round Table recommended the following future policies to be considered and taken into action by parliaments around the world:

- Policymakers should continue to set ambitious goals for lifelong learning and R&D, with special emphasis on funding
- The large-scale development of the NIS is an on-going process. The foremost priority in the internal development of the innovation system is to continually enhance quality, efficiency and relevance
- The cooperation and interaction of the innovation system with other policy sectors must be further developed and deepened
- The conditions for basic research should be strengthened
- The interdisciplinarity and multidisciplinarity in education and research, as well as the cluster approach in industry and economical policy should be improved and extended
- In-depth cooperation of companies, universities and research centres launched within welfare, and information and communication clusters has to be expanded to other clusters, and further deepened
- A global perspective in STIP is important. Innovations should be targeted to integrate the new and the old economies
- More focus should be placed on a deeper understanding of the innovation processes and innovation in general
- Future work force competencies should be developed. Special care must be taken to ensure the availability of well-trained personnel to promote R&D in industry, to increase the supply of knowledge-intensive services wherever needed, and to issue regulations for the protection of intellectual property as well as other regulations which affect innovation
- Parliaments should further develop their own concepts through which they deal with the science, technology and innovation policy. A good example of such concepts is the way the Committee for the Future operates at the Finnish Parliament with a permanent status among other parliamentary committees. Another example is the regional networking between parliaments in Europe through the European Parliamentary Technology Assessment (EPTA)network

These recommendations provide a solid foundation for the development of parliamentary activities in small countries such as Armenia with long-established traditions of civilization.

4.4. The Role of Universities in the Innovation System

Ever since education and research – knowledge and know-how – took centre stage in the development of societies, systematic input has been made into their development. The quality, quantity and right targeting of education and research pose a challenge to all industrial countries. The best universities compete for the best students, and universities have expanded their international provision abroad. Various research projects, studies and pilots are being conducted to identify the measures needed to obtain the best results from the inputs made into education and research and the best impact from outputs in terms of both efficiency and quality-based productivity.

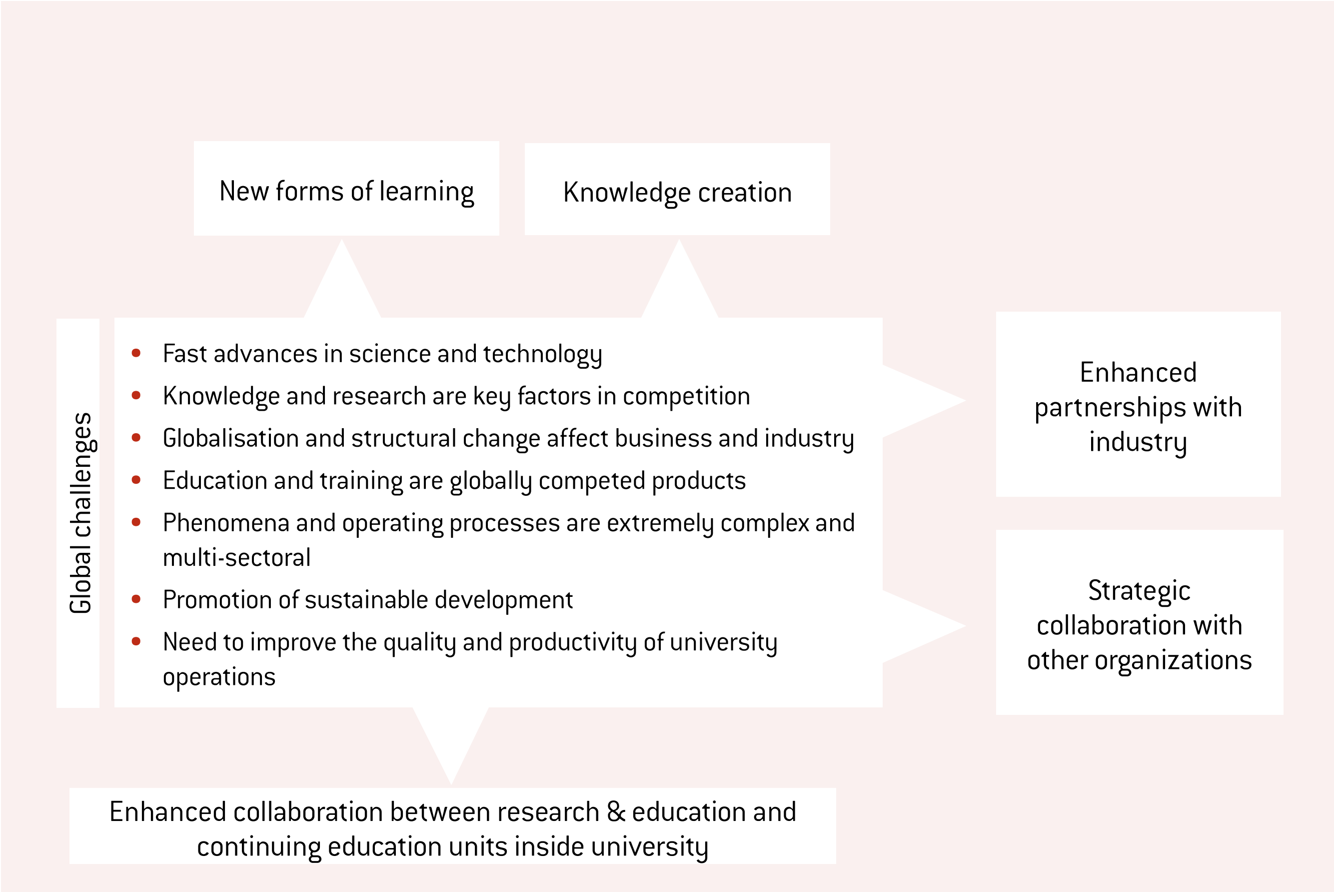
The general objective of science policy should be to raise the quality of scientific research and to improve its visibility and international competitiveness. There are a number of countries that allocate a major share of their public research funding through the Centre of Excellence (CoE) system. The policy aims at developing creative research environments with far-reaching consequences in terms of raising the quality of research and bringing basic and applied research closer together. The outcomes of this system are measured through the innovations with significant commercial and social applications. To reach the desired goals, the centres of excellence are in many countries, in principal, based at universities and only few at other research institutes. The close relationship with education and industrial cooperation is seen to have special importance.

This development means empowering basic university research through increased funding, as well as through structural developments of the concept of CoE and the integration of separate research institutes into universities. The decisions for both funding and new structures are urgently needed in Armenia, too.

One major question is how the university as an institution will be able to manage the pressures and growing expectations directed at it with regard to social, cultural and economic development – whether the university has the internal capacity for renewal needed to lighten its work load in the face of constant new challenges.

The traditional mission of the university is to promote free research and scientific education and to provide higher education based on research. The burning questions in today's debate are how to effectively provide different innovation activities, continuing education and other development services needed by the working life. These questions concerning the university's third mission arise from both the growing expectations

Figure 9: Universities Facing Challenges in a Changing Global Operating Environment



Challenges based on TKK Strategy
Source: Markkula, M. TKK University of Excellence in Adult Education

directed at universities by the users and from the legislative issues involved in efforts to reconcile the university's administrative culture, business and research ethics. The need to address these questions is tangible, because the change taking place in universities' mission and funding structure is systemic, shaking up the institution to its core. Armenian universities need to develop their role to cover not just the basic missions but also to be active and capable to operate as leaders of national continuing education providers, as well as developers and supporters of innovation processes both inside the universities and with industry.

Internationalization is necessary for both the development and utilization of research. A new challenge for universities is to combine in-depth specialized knowledge with versatile expertise for the benefit of users in contract research and in joint projects with them. A special challenge for a small country is the question of critical mass: the capacity to fully participate in international top-level research, while maintaining the capability to create new competencies. For this every small country has to seek its own solutions which can only be based on networking.

Another question for universities to address is to what extent they are able to organize their economies and administrations in a way which will enable their actual provision to evolve and ensure a strong developmental outlook in education and research. At present these demands are not always fully met. It is important in the face of rapidly advancing internationalization to develop and maintain high quality, internal efficiency, a relevant balance (eg. between educational and research missions), and the capacity of both the disciplinary structure and the administration to accommodate to the growing demands for multidisciplinarity. Ultimately the question is how the university itself promotes the education of good teachers and researchers, their career prospects in the university and their recruitment outside the university. Without young researchers the university cannot maintain its dynamism and capacity for constant renewal. Attracting young graduates with highly specialized research to universities and to establish a scientific reputation in international research communities is one of the most important success factors for Armenia. In parallel with this, the Armenian society needs researchers who have interest and competence to operate as business entrepreneurs in the high-tech innovation field.

Innovative learning environments are characterized by a strong commitment to research, determined quality enhancement and competence building, and a genuine desire for results. They are flexibly organized, their linkages with society function well and external financing has an important role in operations. Other features of innovative environments are a clear research strategy and well-defined objectives, great weight given to recruitment policy, and strong international orientation.

In practice, dynamic, innovative research environments vary greatly, but the organizations which have achieved the status of CoE are typically as described above. They are also more attractive as work and study places for the most promising young researchers; in other words, they accumulate competence. This adds to the significance and critical mass of top-level activities. The same level of excellence – dynamic, innovative and attractive research environments – must also be achieved in new fields, not only in those which have already demonstrated their strength.

As this brief account of university development pressures illustrates, the role of universities in modern societies is becoming stronger, but necessitates the support of solutions securing determined and long-term development.

5. Improvements in Knowledge and Work Processes

5.1. Need for Knowledge-intensive Business Services

The view that innovation and technological change are associated only with high-tech industries is widespread. However, innovation and learning are a ubiquitous phenomenon, taking place in high-tech and low-tech industries as well as in services. To be able to stimulate and support innovation processes, a better understanding of different modes, particularities, and specific problems in various sectors is needed.

The so-called low-tech industries see significant productivity increases due to the fact that they become intensive users of modern Information and Communication Technology (ICT) and increasingly adopt technology-intensive production techniques. A main aspect of the new relationship between research laboratories and industry is the exchange of tacit forms of knowledge.

Innovation is a collaborative undertaking that crosses industrial and institutional borders. Low-tech industries need to develop their absorptive and transformative capacities to be able to adopt knowledge created in high-tech industries. High-tech industries, on the other hand, increasingly cooperate with universities and research institutes to jointly create more basic knowledge. And knowledge-intensive business service companies (often called KIBS firms), being in the business of supplying specialized expertise and knowledge, naturally have to cooperate with a number of different clients.

Considering the functioning of innovation systems, it becomes crucial that these contradictions and conflicts of interests can be overcome. In order to resolve them, new organization forms may be needed to encourage understanding among cooperation partners and a more prompt reaction to changing environments. We can think of inter-organizational project groups, independent of external influences, in which trust can be built and common cognitive frames can be developed. But changes in framework conditions may also be necessary to facilitate conflict solutions. In some cases, it may be necessary to change the competition law to allow more intensive cooperation; in others, property rights may have to be changed to stimulate cooperation. Problems may also occur through regulatory inertia and insufficient standardization.

In Armenia the supply of knowledge-intensive business services is weak. The increase in demand and supply are tightly interwoven, the situation thus preconditioning governmental action to encourage public and private developments to meet the needed requirements of innovation and business management markets.

KIBS firms may have an important role to play in arenas where cooperation in knowledge creation and co-management in trans-industrial innovation processes is hampered by different paradigms, heuristics and cognitive frames. However, to successfully fill such a boundary-spanning role, KIBS firms need different forms of knowledge and practices at their disposal. Context-specific scientific knowledge, tacit knowledge and experiences with customers, problem-solving know-how, creativity, strategic thinking, and regulatory expertise are important as are also the use of interactive learning practices and the mechanisms of consensus building.

5.2. Improvement of Processes

Armenian industry, as well as the service sector, is lacking modernization of process and technological development. The effectiveness of technology investments are ultimately measured by the extent to which industrial competitiveness improves. Attention must be paid to raising technological capability to an entirely new level by improving the processes of the different phases of the innovation system.

A critical factor in the economic success of nations is their ability to produce new knowledge and to develop production that effectively utilizes it. Emphasis on research and technology development and improvements in the level of know-how promotes structural change, leads to new industrial development and improves employment. They help to create new jobs in industry, in service and in international business. In addition, they cause radical changes in the pattern of demand for labour. Future jobs will increasingly be generated in tasks related to the production, processing, transfer and utilization of information and knowledge.

The greatest benefit from ICT is obtained when an organization recognizes its own core, supports processes and utilizes its process descriptions in the development of its activities and structures. For example, various service options can be implemented in one flexible process which takes changing needs into account, and where routines and routine knowledge transfers are automated. In public administration this means that the share of self-service processes can and should be increased if at all possible.

Through innovations made possible by ICT, structures in the private and public sectors acquire more process-like characteristics, which transcend organizational boundaries. This leads to productivity increases, especially in services, and improvements in service quality and accessibility.

There must be a shift from traditional functional management to process-like activities, where people are not expected to be able to do everything by themselves. By rationalising activities it is also possible to slow down and make better use of the new work and e-work possibilities afforded by ICT. New usage habits are important for implementing process-like activities. Significant results can be achieved with process development, but the benefits can be multiplied when the process management itself is improved.

Productivity is a part of an organization's central performance, and at the same time, an essential element of the core processes and support processes. Productivity can have an effect on an organization's competitiveness and profitability, which depend largely on the organization's external operating environment.

Recognizing and developing processes is the basis for developing an organization's management system. We can imagine the work community as consisting of three interconnected levels: [i] the level of interaction between people, [ii] the organizational level, which formally defines and determines people's activities and which steers the community's operation processes, and [iii] the level of information systems and tools. In the development of activities, the relationships of dependence and impact between levels have not received the attention they deserve. The use of process descriptions can turn information systems and ICT tools into a great source for increasing productivity.

Quality is intimately linked to technology and training policies. The overall quality of goods, services and business activities has become an increasingly important factor in sustainable competitiveness. In many industrialized countries, the public sector has begun to follow an active quality policy. The focal points of the national quality policy are the development of the quality-related aspects of technical and educational infrastructure to the highest possible international level, the support of industries' own quality promotion schemes, and the development of the quality of public-sector operations. National strategies need to be closely linked with the private sector. These issues of productivity, process development and quality are too often forgotten when defining the essential elements in the STIP.

5.3. Lifelong Learning & Continuing Education

For the adult population, lifelong learning is the motivated and planned activity of the individual to ensure his or her own professional development. There are, however, many obstacles on the individual's professional career path. Therefore Continuing Professional Development (CPD) needs to be organized as a well defined process affecting, through the job and related training and education, the development of the individual's mental abilities, knowledge, and skills. This can be achieved only when the

individual and the company have clearly defined their goals and these goals support each other.

The functional basis of providers of continuing education based at universities is the systematic application of the lifelong learning principle into practical measures that support each other. The starting point is the fulfilling of the training and development needs of the individuals and their work organizations. Continuing education services build on the expertise of the university and the whole scientific community, as well as on combining this with the expertise of national and international companies, education, training and research organizations and experts.

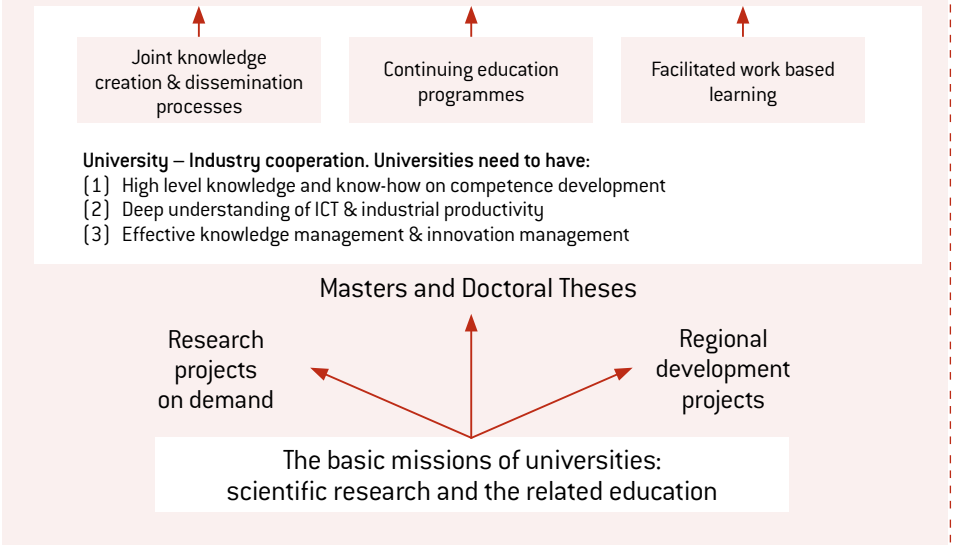
The fundamental principles of the educational policy of the EU are to support and enhance cooperation between universities and industry, lifelong learning, technology-enhanced learning and European networking. These objectives mean that continuing education will become even more central than university education. Therefore, it is important that the organization and implementation of continuing education is further integrated into the other university activities to achieve synergistic interaction and effective operations.

Continuing education centres within universities need to carry their public educational policy responsibility while operating in accordance with effective business principles. Each university should define the core business areas that give this unit the right to exist. These are typically:

- The implementation of long-term continuing education programs that utilize the specific expertise of the university
- The organization of short courses and events that market the expertise of the university
- The functioning as the university's expert unit for professional development and lifelong learning
- The organization of regional and sectoral networks for training cooperation and technology transfer
- The creation and utilization of international contact networks
- The offering of innovative training and development services through organizing the cooperation of the different players

Changes in work culture and performance measures throughout the working life give universities a special role, as well as advantages, to develop and manage top-quality continuing education products and services. The advantages of universities are that

Figure 10: Universities Have a Key Role in Industrial Change towards Competitiveness



Source: Markkula, M. TKK University of Excellence in Adult Education

they operate close to the latest research results and with the experts of knowledge management.

Universities have awoken to this change. At the same time, the competition for reputation, students, teachers, financing and the best partner companies is becoming fiercer. The Bologna Process[2] has given the universities a boost, encouraging them to design their brand for the international markets. In the future the amount of adult students and those engaged in working life are anticipated to further increase. University students will be more multicultural, multidisciplinary and the age structure will be more extensive than today: the heterogeneity of the clientele will grow.

2. The Bologna Process is named after the Bologna Declaration, which was signed in the Italian city of Bologna on 19 June 1999 by ministers in charge of higher education from 29 European countries. Today, the Process unites 46 countries - all party to the European Cultural Convention and committed to the goals of the European Higher Education Area. An important characteristic of the Bologna Process - and key to its success - is that it also involves European Commission, Council of Europe and UNESCO-CEPES, as well as representatives of higher education institutions, students, staff, employers and quality assurance agencies. The overarching aim of the Bologna Process is to create a European Higher Education Area (EHEA) based on international cooperation and academic exchange that is attractive to European students and staff as well as to students and staff from other parts of the world. www.bologna2009benelux.org

As a result of the development, and when scrutinized from the perspective of adult education, one must, in the future operating environment, be capable of recognizing and understanding the internal value creation processes of the customers and partners and of developing education supply meeting the needs of these processes. In other words, the success factor draws from controlling not only the competence needs of the customers but also a far larger value network. In such a situation the starting point of organising education is, in particular, being able to recognize how the clientele of the customers operate and which new competence needs this induces.

From the university's point of view this means that the customer – either a private person or an enterprise – must be known better than ever before. One must possess expertise not only in science but also in what brings added value to the customer. In practice this translates into understanding customer value networks, and through this the competence needs of the customer, as well as interest in creating and maintaining diverse customer relations. An important issue is how to create, manage and maintain customer relations in the future.

This means that strategic decisions have to be made on how the university will be structured and what service it will supply to meet future challenges. Armenia is also facing these challenges, as well as having the need to make strategic decisions.

6. Recommendations

6.1. Armenian History

The Armenian Story to be Created to Engine International Collaboration

An internationally attractive knowledge economy needs to have something special to offer. Collaboration activities especially in the international STI field are always based on the win-win principle. Armenia should take full use of its specific strengths by creating its own brand: "A story with key success factors why Armenia is attractive for international STI cooperation."

Specific Armenian strengths:

- Some specific elements deriving from the ancient history of Armenian civilization
- Some evidence for public commitment to increase well-being and high levels of scientific research
- Some evidence for the important role of STIP at the highest political level

6.2. The Way to the Welfare Society

Science Needs to be Integrated into Technology and Industry Policies

Even at the highest developed level reachable through successful development activities, science does not create sufficient economical success for the welfare society. Science needs to be integrated into effective technology and industry policies.

In the global rivalry for competitive edge, when a small nation is looking for partners, customers and investors, high-quality and visible evidence can be created by describing the value chains:

- From basic research through innovations to production
- From basic education through higher education to continuing education and professional development

Armenia has the needed resources and energy to initiate and implement these value chains, and later on to further develop them into a national value network with international linkages and well structured and well functioning key processes. Special attention and activities are needed to create the necessary processes in order to achieve this national understanding of and commitment to value chains and networks.

6.3. Strong Commitment by all Major Actors

National Innovation System Needs to be based on Lifelong Learning

A small country has some typical advantages when promoting the creation of a joint political commitment towards an effective National Innovation System (NIS). The most important one is that the NIS needs to be based on a well-defined and effectively implemented lifelong learning policy.

Armenia has effectively started this development through better education and various STIP laws approved within the last few years. This is a solid foundation to build on. However, strong and well planned steps are needed at the parliament level. There are several activity options through which the general attitudes can become more favourable towards education and STI. Such are:

- Strengthening the parliament debate by preparing a special Armenia 2015 Foresight
- Having the Prime Minister and other ministers to declare specific resolutions/ statements to the parliament on a regular basis for debate
- Creating a permanent Committee for the Future inside the parliament's structures in parallel with other parliament committees

6.4. Effective Utilization of Information and Communication Technology (ICT)

Need for the National Information Society Program

The development of ICT, particularly the Internet and mobility, and the global development and network economy they make possible, have changed people's daily lives, social and organizational structures as well as the development of countries and entire continents as profoundly as the industrial revolution did in its time. Information society development has reinforced equal opportunities and equality of people and regions as well as created a framework for global responsibility and sustainable development.

Armenia needs a National Information Society Program and later on, based on its outcome, a National Knowledge Society Strategy. In defining these, the European Union experiences and activities should be fully utilized. The EU's information society strategy that extends to 2010 is a key part of *The New Lisbon Strategy* and directed at the information and communication sector that is strongly driving the EU economy. The three most important aims of the *EU i2010 Strategy* give a good base for Armenia to set its goals:

[1] A common European information space that promotes open and competitive internal markets in the information society and communications field

[2] Increased innovation and investments in the ICT field in order to promote growth and create new and better jobs

[3] A European information society that promotes inclusion as well as growth and employment in accordance with sustainable development, and in which public services and improvement of the quality of life are of primary importance.

The aim of the Armenian Information Society Program should be to boost competitiveness and productivity, to promote social and regional equality and to improve citizens' well-being and quality of life through effective utilization of ICT. National and international cooperation needs to be of key importance in the implementation of the program. In addition, the program should build up citizens' confidence in information society services by improving data security and protection of privacy. The Information Society Program should include at least the following sub-sectors:

[1] Telecommunication and infrastructure

[2] Citizens' ability to utilize the information society and security

[3] Training, working life development, research and development

[4] Utilization of ICT in public administration electronic commerce and digital contents, international dimension

6.5. Effectiveness of STIP

State Committee for Science (SCS) to have a Strong Role

The Armenian STIP is too scattered and its implementation has been too weak. Thus the newly established SCS should have a key role in carrying out the general STI guidelines already approved by the law. This can be organized by means of either merging the ministerial STI activities and establishing a new STI ministry or increasing the SCS's power as a national STI integration and funding body directly under the President's and/or Prime Minister's leadership.

The role of SCS needs to be strong and broad, since managing the change defined by the government's guidelines is a real challenge for Armenia. The important STI elements are described in the recommendations in this report. To encourage and facilitate the needed industrial and especially corporate development the SCS should have at its disposal instruments for funding and running KIBS, as well as for funding and managing incubator and other processes in the seed and early phases of start-up companies.

6.6. International Benchmarking, Evaluation and Assessment to be Organized

Science, Technology and Innovation Policy (STIP) to be on a Solid Base

Benchmarking, *evaluation* and *assessment* are terms used broadly for the practice of measuring performance and analyzing the impacts of different actors and their operations. Credibility, which is especially important for attracting desired partners for international cooperation, is enhanced by having substantial evaluation carried out by auditors external to a program and/or activity, and also by having multiple evaluators using a variety of methods that best fit the issue at hand.

In the field of STI the methods and techniques of benchmarking, evaluation and assessment, while in many respects impressive, are challenged especially by the difficulty of the task of measuring the impacts of STI programs and other activities, which are in most cases very complex by nature. In recent international development, practitioners at the forefront are not only applying state-of-the-art approaches, but also organizing the needed process type developments – the whole activity is a learning process with regard to content, methodologies and networking by using experts through distance as well. There are many on-going developments in the methodology and practice to better meet the needs of policy and decision making so as to benefit the Armenian policy options.

For Armenia all these activities – *benchmarking*, *evaluation* and *assessment* – are needed. The arrangements of these should be one of the primary activities of SCS. Benchmarking by comparing Armenia's own practice against other good practices offers the country a way to learn what and how others are doing, and to obtain a deeper understanding of the processes themselves. This serves the urgent needs of SCS in developing their management processes to be based on the best networking and knowledge management practices in order to meet the Armenian requirements in securing the desired future.

6.7. Funding of Armenian National Science

Enabling the Existing Top-Level Research to be Upgraded to International Cooperation

The scientific and political foundation of Armenia was laid out particularly during the Soviet Era on the vast group of institutions specialized in diverse disciplines. Currently these institutions desperately need major reforms and significant additional funding. In this development it is essential to take into account that the international trend indicates clear attempts to strengthen the role of universities in research activities and the university-industry collaboration.

The most natural solutions for managing this area are the recommendations listed under recommendations 6.8 and 6.9 (sections below), meeting the needs of an effective STIP and helping benefit from the experiences gained in small states successful in transferring at a rapid pace to the deployment of funding competition and other methods typical of the networked economy.

6.8. Science Institutes to be Integrated into Universities

Creating an Integrated Policy Working Towards a System of Centres of Excellence (CoE)

A large amount of dispersed institutions built on too weak a foundation of operations must be reorganized one way or the other to redirect their activities towards solid growth. The natural way of doing this is to integrate these institutions into universities in a way that simultaneously serves the establishment and effectiveness of university-hosted research activities as well as enhances their attractiveness in terms of both national and international education and research. This would help create a tradition of competed funding in the university world and simultaneously help acquire a base for a gradually developing CoE, a research institution network altering the practices of the entire university system.

6.9. National STI Priorities to be Defined and Implemented

Begin with the Most Important Activities to Create a Solid Base for Success

The government's decision in 2005 on the implementation, during the years 2005-2010, of the law of STI activities includes, among others, Section 3.2 *Setting Priorities*. Now when the SCS – which is the body having the responsibility stated in this decision in Section 6.5 – is established, it should start with a strong role in defining and implementing the priorities, as soon as possible. Benchmarking the national STIP in other countries indicates that priorities of this kind are based on thorough evaluation processes, which at least to a certain extent are carried out by independent international evaluators. The processes in carrying out these activities needs to be prepared carefully. Thus, when some urgent measures are needed and the evaluation processes are not yet prepared, the following actions are proposed here.

The government should make an important decision by requesting the SCS to organize a process through which a CoE program would be established. The target is to integrate the best research institutes to operate as part of the top universities, and to secure their basic funding for several years. In the first phase this means status and proper funding e.g. of five to ten centres, the criteria in the nomination process being:

(1) The research plan is a joint effort of an existing research institute and a university

(2) In the plan, the research focus is clear and targeted to the international level

(3) The role of universities is, in particular, to show the benefits coming from this research activity to universities' education and innovation processes

(4) The plan includes a clear action plan through which the CoE within the university can reach the desired impacts within the society

6.10 Towards Effective STI Processes and Knowledge Management

State Committee for Science to Motivate and Assist in Change

By increasing investments in R&D and aiming more at the development of knowledge-intensive services throughout the whole NIS, a significant effect on economic growth and productivity development can be achieved. Especially important among these services are new network-culture services and knowledge sharing made possible by ICT in the working life, in teaching and learning, and in services integrated into products and production.

Well-organized processes increase productivity and innovativeness by decreasing partial optimization between units and individuals, and by allowing a more efficient utilization of ICT. When routines and even complex processes are operationalized through effective knowledge management as visualized collaborative processes based on networking, many resources in the NIS are freed to carry out tasks that produce more added value, such as better customer services, development and marketing of new products, lookout for new partners, development and innovation of operations, and particularly knowledge creation in research itself.

Armenia needs an effective knowledge management system where the focus is on the processes needed for knowledge creation and the dissemination of the existing information for wide use by many actors who need this kind of information and knowledge. The SCS seems to be a natural body for carrying out this initiative in close

cooperation with actors in foreign countries which are well known as the leading developers in the field of knowledge management.

6.11. Innovation Policy Needs to be Highlighted

Industrial Development Needs to be Integrated into Science and Education

The Armenian industry needs a strong boost one way or another. This cannot be achieved in a year or two, but instead by defining a long-term vision and having in the implementation a special focus on the actions which have also short-term impacts. There are still signs indicating that the old bureaucratic structures and management practices in Armenia may have too strong an impact on hindering the needed development. Change is always an extensive learning process, which needs to be openly organized and jointly created.

The desired change can be reached by creating a step-by-step policy on:

(a) Increasing the understanding of the processes of innovations, innovation management and innovation leadership

(b) Organizing joint high-level executive education programs for top-level managers from both public and private sectors

(c) Creating new incentives for entrepreneurship, including special training programs, tax incentives and organizing action for venture capital funds

(d) Increasing the attractiveness of technology and innovation studies

(e) Integrating university studies and research into industrial development better than at the moment

(f) Creating special business-oriented study programs which are linked to service science and product development and thus increasing the attractiveness of business-focused scientists

(g) Creating joint university-industry technology programs in which experts from both sides operate towards new innovative applied research findings and their industrial implementations

6.12. Continuing Education Centers to be Created within Universities

Encouraging Professional Development of Industrial and Scientific Competencies

High productivity is of primary importance in every society, but it can no longer be achieved by traditional methods and concepts, it cannot even be measured by using traditional tools. Decisive for the economic foundations of national success and

well-being is the intangible capital of citizens, work communities and society and its continuous capacity for renewal.

The increase in the knowledge capital of work communities is based on the systematic professional development and capacity for self-renewal of the communities and of individuals, and the dynamic management of processes. This national asset for economic growth and quality of life should be adopted as an elementary target in the Armenian policy.

A significant addition to the required competence potential on the way to welfare society can be obtained if research and education development are connected to each other and to the required working life development by launching activities by means of which universities can establish strong units managing continuing education and development services for working life. An additional element boosting desired working life development is the creation of incentives helping draw young expert expatriates back to the home country.

To implement this development, investments should be made to organize the continuing education in Armenia using the best international concepts of university-based lifelong learning institutes. The primary target groups should be the managers, knowledge professionals and others having important tasks in work communities.

6.13. Creating a National Science and Innovation Park in Yerevan

The On-going Technopark Development Needs to be Strengthened

The existing Technopark plans are important and guide the actions in the right direction. However, the existing locations and structures of university buildings, streets and other infrastructures give a good opportunity for more focused and ambitious city planning of this large area within the center of Yerevan. In a way there exists a unique opportunity to integrate science, business and culture to create an ideal location for new innovation establishments and other developments in order to attract not just local investments but also to create high international interests towards investments.

There is so much new building construction going on and under planning that the decisions are needed fast to start ambitious city planning around the area the core of which is being formed by the three universities (Yerevan State University, State Engineering University of Armenia and Yerevan State Medical University). This momentum should not be left unused. It can be created to become the major Armenian attraction not only to foreign capital investments but to international intellectual capital flow as well.

6.14. From International Cooperation to In-depth Collaboration

Effective Use of Existing Opportunities

The historical roots of Armenia display its visible role in international communities of practice and scientific development. In addition to cooperation with the Russian scientific life, Armenia should determinedly seek cooperation with the EU's educational and research activities, as well as with global knowledge industries, not forgetting the global actors such as the World Bank and UNESCO. Compared with other countries, Armenia has a supplementary instrument at its disposal – an extensive global Diaspora.

For Armenia the EU programs can be a valuable resource in establishing contacts with Western European STI and industrial actors for cooperation. In turn, allowing Armenia to increase cooperation with the desired partners. Armenia should focus on a few specific areas where the reputation of high-level Armenian innovation is evident. The Seventh Framework Programme (FP7) is designed to support a wide range of participants: from universities, through public authorities, to small enterprises and researchers in developing countries. The doors are open for Armenian partners.

A possible target for negotiations on the governmental level is the membership in EUREKA, a pan-European network for market-oriented industrial R&D with a special focus on innovative products, processes and services. Several non-EU countries are members of this network, among them Russia and Ukraine, or members have committed to other kinds of special affiliation arrangements.

An example of the effective use of existing opportunities could be the EU TEMPUS programme which has already been used for Armenian higher education development. However, within the top-level university developers in most EU countries, TEMPUS is no longer seen as very attractive for large-scale development. In the case of Armenia, TEMPUS could be used to create an innovative university – industry lifelong learning platform i.e. linking basic education, continuing education and post-graduate education to operate in a symbiotic coherence inside Armenia and with this kind of focus to attract the most relevant international partners to work with Armenia. Furthermore, using some other resources in addition to these TEMPUS funds, this could be expanded to cover the development of a science and innovation park system and other cooperation activities with working life, as described in sections 6.11, 6.12 and 6.13 in this list of recommendations. Thereby, this kind of development project would be of special interest to the needed top-level EU partners.

Appendix

APPENDIX I

Country Information

Total Population (millions)	3.0 (2005); 2.8 million (1975)
Population growth (annual %)	– 0.1% (2005-2015)
Urban population (% of total)	64.1 % (2005)
Rural population (% of total)	35.9 % (2005)
Population density (people per sq. km)	107/sq km (2005)
Surface area	30 000 sq km (2005)
Capital	Yerevan (population – 1,103,488 people)
Major cities	Gyumri, Vanadzor
Official language	Armenian
Religion	Armenian Apostolic 94.7 %, other Christian 4%, Yezidi (monotheist with elements of nature worship) 1.3%
National holidays	April 24 (Genocide Remembrance Day), May 9 (Victory and Peace Day), July 5 (Constitution Day – adopted in 1995)
GDP (US$ billions=1 000 million)	4.9 billion (2005)
GDP (PPP US$ billions)	14.9 billion (2005)
GDP per capita, annual growth rate (%)	4.4% (1990-2005)
Average annual change in consumer price index (%)	0.6% (2004-2005)
PPP gross national income (per capita $)	$5 060 (2005)
Agriculture (% of GDP)	21 % (2005)
Manufacturing (% of GDP)	21% (2005)
Industry (% of GDP)	44% (2005)

Services (% of GDP)	35 % (2005)
Official exchange rate (local currency units to $)	Dram per US dollar = 416.04 (2006)
GDP implicit deflator (average annual % growth)	4.2 % (2000-2005)
Revenue (% of GDP)	19.3% (2005)
Cash surplus/deficit (% of GDP)	– 1.0% (2005)
Exports of goods and services (% of GDP)	27 % (2005)
Primary exports (% of merchandise exports)	29 % (2005)
Manufactured exports (% of merchandise exports)	71 % (2005)
High-technology exports (% of merchandise exports)	0.7 % (2005)
Imports of goods and services (% of GDP)	40% (2005)
Merchandise imports ($ millions)	1.7 billion (2005)
Food (% of total)	18 % (2005)
Agricultural raw materials (% of total)	1% (2005)
Fuels (% of total)	16% (2005
Ores and metals (% of total)	3 % (2005)
Manufactures (% of total)	62% (2005)
Total external debt (billions)	1.8 billion (2005)
Debt and interest payments (interest payments % of revenue)	2.2% (2005)
Total fertility rate (births per women)	1.3 (2000-2005)
Adult Mortality rate, male (per 1 000)	204 (2001-2005)
Adult Mortality rate, female (per 1 000)	92 (2001-2005)
Infant mortality rate (per 1 000 live births)	26 (2005)
Life expectancy at birth, male (years)	68.2 (2005)
Life expectancy at birth, female (years)	74.9 (2005)
Dietary energy supply (DES)(Kcal/person/day)	2 260 (2001-2003)
Population below income poverty line (%) $4 a day	80.5% (2000-2004)
Telephone mainlines(per 1 000 people)	192 (2005)
Cellular subscribers (per 1 000 people)	53(2005)
Personal computers (per 1 000 people)	66 (2005)

Households with television (%)	91% (2005)
Internet users (per 1 000 people)	53 (2005)
Adult literacy rate (% aged 15 and older)	99.4% (1995-2005)
Youth literacy rate (% aged 15-24)	99.8% (1995-2005)
Net primary enrolment rate (%)	79% (2005)
Net secondary enrolment rate (%)	84% (2005)
School enrolment, tertiary (% gross)	28% (2007)
Public expenditure on education (% of GDP)	3.2% (2002-2005)
Military expenditure (% of GDP)	2.7% (2005)
Public expenditure on education (% of government expenditure)	15.0% (2005)
Female, Estimated earned income (PPP US $)	$3 893 (2005)
Male, Estimated earned income (PPP US $)	$6 150 (2005)
Seats in Parliament held by women (% of total)	9.2% (2007)
Pre-primary and primary[1]	16% (2002-2005)
Secondary and post-secondary non-tertiary[1]	53% (2002-2005)
Tertiary[1]	30% (2002-2005)
Scientific and technical journal articles	175 (2003)
High technology exports ($ millions)	5 million (2005)
Patent applications filed (residents)	151(2004)
Trademark applications filed (residents)	1,598 (2004)
Share of women in total numbers of researchers in S&T (%)	46 % (2007)
Research and development (R&D) expenditures (% of GDP)	0.3% (2000-2005)
Tertiary students in science, engineering, manufacturing and construction (% of tertiary students)	7% (1999-2005)
Primary, Gross enrolment ratio (% of relevant age group)	94% (2005)
Secondary, Gross enrolment ratio (% of relevant age group)	88% (2005)
Tertiary, Gross enrolment ratio (% of relevant age group)	28% (2005)

1. % of total current public expenditure on education

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APPENDIX III

Higher Education in Armenia

According to the Constitution of the Republic of Armenia, compulsory school education lasts ten years and is free. Since 2001 secondary education has been transformed to 11- year and, in 2006 to 12-year programmes. Since 1991, centralized state entrance examinations are organized for the different higher education study programmes. The Knowledge Assessment and Testing Centre, established in 2006, will replace the entrance examination system in the future.

There are 16 state universities (with 14 branches) and 75 private universities (of which 33 accredited by the state) with 61,000 and 15,000 students respectively. Non-state universities are totally financed through tuition fees whilst state universities have both state-supported and fee paying students.

The higher education system in Armenia has been significantly reformed over the past decade, starting with the Law on Education in 1999, the State Programme for Educational Development for the period 2001-2005 in 2001, the Strategy for Higher Education in 2002 and the Law on Higher and Postgraduate Professional Education in 2004. Since 2004 all universities have adopted the two cycle system of education and are now focusing on changes to the contents of courses, internationalization and improving internal efficiency.

The first cycle of studies in Armenia typically lasts four years and leads to a Bachelor's degree (*bakalavri kochum*). The second cycles leads, after two years, to a Master's degree (*magistrosi kochum*) specializing in a given field. Students then carrying out scientific research work for two years (*aspirantura*) are awarded after successfully preparing and defending a thesis, the *gitutitnneri teknatsu* (Candidate of Science). After *aspirantura*, students can engage in Doctoral studies (leading to a Doctor of Science degree) at one of the research institutes of the Armenian Academy of Science. The main difference between the Candidate of Science and the Doctor of Science qualifications is that the latter can only be awarded by Academy of Science research institutes.

A new impetus for development was given by the Bologna Process, which Armenia signed up to in 2005. Through its participation, the country is now endeavoring to make concrete and significant strides towards adopting a student-focused approach to education.

In November 2006 five Bologna groups were established by the Ministry of Education and Science. Each group, composed of representatives from different universities, is responsible for one of the following areas: Two cycle system of education, ECTS, Quality

Source: UN Cartographic Section, Republic of Armenia, No. 3762 Rev 4, May 2008

Assurance, Mobility and Finance. Armenian universities are now to start piloting a credit system in 2007 and a national Quality Framework is currently being discussed. The National Development Program for Education for 2008-2015 is currently in preparation and is being discussed amongst a wide range of stakeholders.

Years of compulsory education: 10

Gross enrolment ratio* (ISED levels 5 and 6): 26.2 % (2004)

Number of higher education institutions: 16 public, 75 private

Bologna signatory country since: 2005

* The nation's total enrolment in tertiary education (regardless of age), as a percentage of the population in the official age group cooresponding to the level of education.

For further information, contact the National Tempus Office at sctemp@arminco.com or at www.tempus.am

Source: National Tempus Office, Armenia, 2008

APPENDIX IV

Summary: Armenian STIP Review

Institutional Framework

Legislative and normative legal field of the sphere of science is regulated through:

- RoA Law *On Scientific and Technological Activity* adopted by the National Assembly of Republic of Armenia (RoA)
- *Concept for Science Development in the Republic of Armenia* approved by the RoA Government
- S&T cooperation, intergovernmental agreements have been signed and business programs have been implemented with numerous countries

Positive Factors in the Scientific Sphere

- Scientific capacity (which comprises about 20,000 persons), scientific organizations and schools have certainly been kept
- Some scientific directions gradually taking their place in the international scientific market
- Availability of authorized public administration bodies
- Regulation of the legislative field of the sphere of science
- Certain regulation of science financing from the state budget: implementation of different financing ways from the state budget
- Increasing role of the scientist as a science subject

Factors Preventing Science Development

- Slow process of formation of the effective management system and incomplete formation of the universal public administration system
- Financial restrictions
- Slow formation of the effective system for creation of appropriate conditions and implementation of scientific findings for innovation activity
- Scientific sphere marketability low level
- Incompleteness of target policy for scientific capacity reproduction

- Lack of scientific and pedagogical staff in scientific and higher educational institutions
- Outflow of qualified scientific personnel, especially young people
- Absence of comprehensive universal scientific information system
- Lack of modern and up-to-date scientific and technological basis in the sphere of science

Science, Technology and Innovation Strategic Plan

- Formation of universal public administration system of science
- Increase of efficiency of scientific institutions' activity
- Ensuring reproduction of scientific capacity
- Necessity of modernization of infrastructure, material and technical basis in scientific sphere
- Clarification of funding and ways, increase of efficiency
- Creation of independent experimental scientific system
- Clarification of priorities in science
- Integration of science and education
- Marketability of scientific findings bringing them into domestic market and external market

Source: Prepared by Armine Karapetyan, National Statistical Service of the Republic of Armenia UNESCO Seminar-Workshop on STI Indicators – Trends and Challenges. 18-20 September, 2007 Moscow, Russian Federation

APPENDIX V

Conception on Improvements in the Science Sector in the Republic of Armenia

Approved by the Armenian Government in July 2007

The present conception is a system of propositions underlining the role and significance of science, exposing current problems in the sector and determining the ways of settling them.

Scientific, technological and innovation activities are considered the main factors of social and economic growth in the modern world. Science serves as cornerstone for paving the way for a competitive economy in the shortest possible period of time. Science-based production is the factual and rapidly developing sector which greatly influences other branches of production.

In the 21st century social welfare and development in Armenia can be reached due to science. Settlement of social and economic problems, civil consensus and establishment of democratic society can be achieved through the increase of intellectual property which in turn depends on development of science and education.

Considering the development of science and technological progress of special strategic significance, it is essential to foster effectiveness of state policy directed to the sector. Economic rise in Armenia can be sustained if the results of scientific research are successfully implemented.

State of Affairs in Science Sector

Science in Armenia has traditionally enjoyed state attention as being an essential factor of national security, economic growth and educational, cultural and social progress. Scientific potential in the RoA constitutes nearly 20,000 people. Almost 7,000 scientists and researchers are enrolled in projects and programs supported by state budget. During the years of independence, scientific potential have been maintained to some extent, non-governmental scientific organizations and funds have been established, a government-funded research program and project system has been implemented, the independence of scientific institutions has extended, and linkages with the international scientific community have been established. Legislative base has to a certain extent improved. The principles of state policy in the science sector are formulated in *On Scientific and Scientific-technical Activity* law (adopted in December 2000) and in the *Conception of Science Development* (approved by the Government of the RoA in April 2001).

Despite the promising activities mentioned, the process of fundamental improvements in the science sector was delayed, entailing numerous problems demanding urgent settlement.

The disintegration of scientific institutions (ministry-run scientific organization, academy institutions, centers and universities) combined with the absence of a united state governing body are hurdles that impede the development and effective realization of a state policy. A non-productive state governing system is a result of such factors as departmental interest and human element.

Existing scientific infrastructure resources fail to provide effective utilization of scientific potential.

The lack of independent scientific expertise system, unfocused state policy in the sector, insufficient level of commercialization of scientific results, poor conditions for innovation activities are those obstacles that inhibit development of the sector.

An unfocused state policy for the growth of scientific potential results in a low level of rejuvenation of scientific potential in scientific organizations and universities. One of the burning issues is the prevention of the exodus of young specialists. Insufficient levels of educational curricula and exodus of young specialists endanger the maintenance and the development of scientific schools as well as the maintenance of scientific personnel.

International collaboration in S&T is inadequately organized. The government fails in developing a focused and more reasonable policy to integrate with international standards of science development priorities. Scientist's copyrights are not firmly defended. The lever of commercialization and export of scientific products leaves much to be desired.

The lack of a united scientific information system and scientific-technical base combined with a slow process of integration of science and education are also among the negative factors.

One of the main reasons for the present situation is the insufficient level of government funding (it constitutes 0.3% of gross domestic product). Moreover, state resources do not completely meet state demands.

The present situation urges the creation of effective and modern centers of excellence in Armenia. The improvement strategy demands a systematic and constructive activity on the part of each government body. Failure may endanger the future of the country.

Urgent Settlement of Existing Problems

The primary objective of improvements in the science sector is the creation of a knowledge-based economy and in this process strong state leadership is needed. On the one hand, improvements should be realized along with the promotion of effective governance, modernization and improvement of scientific infrastructure, and on the other, along with defining science and technology development priorities in Armenia and initiating activities of scientific institutions according to these priorities through focused training of scientific personnel and fostering their activities. A detailed schedule of measures and mechanisms for improvements should be substantiated by enhancing effective governance of the sector combined with the application of specific approaches and enrollment of skilled personnel.

The Primary Steps are as Follows:

- Establishment of a united state science governing body
- Increase in science funding, clarification of funding forms and mechanisms, enhancing productivity of funding
- Enhancing effectiveness of activity in scientific organizations
- Maintenance of focused and effective reproduction of scientific potential
- Modernization and creation of new infrastructures, material and technical base
- Introduction of independent scientific expertise system
- Definition of science development priorities
- Integration of science and education
- Fostering commercialization of scientific results and exporting to foreign market

Establishment of a United State Science Governing Body

The establishment of a united state science governing body should be carried out through making precisions in overall governing levels.

In line with the above mentioned, the status and competences of the authorized body should be considered. This body is to become a State Committee of Science, under the auspices of the Ministry of Education and Science, which will be authorized to develop and realize the state policy in the science sector. The Council of Science and Technologies, that will be attached to the Prime Minister, will discuss and give approval to main principles of state policy in science sector and settle the integration problems in way of its realization.

Increase in Science Funding, Clarification of Funding Forms, Enhancement of Funding Effectiveness

The current issue firmly depends on the realization of programs included in mid-term expenditure state programs that are envisaged by conceptual propositions. Increase in funding will be supported along with the improvements of the science sector with essential and rapid growth of state budgetary resources directed to the science sector. Favourable conditions should be created for attracting non-budgetary resources and foreign investments. In line with the above mentioned, the principles of co-funding should be fixed in legislature which will enable integration and regulation of involvement of foreign resources. In this respect program and thematic projects should be realized on a competitive base by means of scientific funding which is to be supplied by the government. International and regional projects on science development should be realized and Armenia will be encouraged to actively participate in them. It is also essential to come into close contact with scientific Diaspora, organize joint workshops and summer schools. Integration into the European Research Area (ERA) is also one of the pressing issues. Hence, the State faces serious problems in organizing new models of science governing, implementing new funding mechanisms, developing new organizational approaches toward institutions with same scientific interests.

Such funding mechanisms should be developed where funds will be directed to meet state needs. Multi-form type of funding should be preserved and it should be carried out on a competitive base. All the projects and proposals should be well-grounded. Hence, funding forms should be improved and the criteria and mechanisms should be defined more accurately.

- Funding on base principles is to be realized with the aim of sustaining and developing those scientific organizations (centers) and their infrastructures that are involved in researches of basic and applied character.
- Projects of strategic importance should be carried out under targeted funding in the form of research projects. The majority of projects are to be of applied character and be proposed by corresponding departments. The principles of targeted funding must be improved and made consistent with tasks set forth by the State.
- Thematic funding should be transformed into a grant – donating system. Thematic funding is directed to separate researches in accordance with science development priorities that can bring about new scientific researches and scientific-technical developments.

Enhancing Effectiveness of Activities in Scientific Organizations

Enhancing effectiveness of various ministry-run organizations can be achieved by focusing their activities toward the above mentioned principles of science development. Organizations will realize their activities and get base funding in case of realizing a focused activity. The primary step in enhancing the effectiveness of activities is creating a base on their scientific and technical facilities that will be followed by institutional reformations. Organizations of a similar scientific orientation should be united and they should be turned into scientific centers with the status of a fund (maintaining financial and organizational independence of separate sectors, by implementing principles of contemporary management). Within the organizations the director's and scientific council's duties and competences should be clarified by implementing principles of contemporary management and securing settlements and discussions on science issues from administrative infringements. The management of the scientific council will be carried out under the leadership of a scientist representing the given scientific field.

University science sectors should have a clarified organizational and financial status, independence and in some cases maintain the status of juridical person. Science, technology and innovation type of institutions (technical parks, business-incubators, technology transfer centers, etc.) can be founded on the basis of certain organizations. Possibility centers should be created to provide juridical assistance to scientists and to contribute to the export of scientific products to domestic and foreign markets.

Organizational and juridical status and competences of the National Academy of Sciences of the Republic of Armenia will be formulated in the new law *On Scientific and Scientific-technical Activity*. Herewith, the Academy's competences imposed on the part of State will be clarified, the relationship between the Presidium and Academy institutions and centers will be regulated. The Academy's role as a consultant will be firmly fixed. The Academy will be authorized to carry out evaluation and review of certain scientific projects.

Reproduction of Scientific Potential

With the aim of creating favorable conditions for the reproduction of scientific potential, an analysis of scientific potential should be carried out and a careful evaluation of the demand for specialists must be made. In this respect the creation of a national bank is essential and it should include, as well, a database on Armenian scientists working abroad. A plan for the development of scientific potential should be cultivated. It will be focused on the rejuvenation of scientific personnel. Contractual basis should be created for renowned scientists and high salaries should be provided to them. Certain grant-donating and scholarship programs should be implemented for young scientists and for post-graduate students which will contribute to the rejuvenation of scientific personnel and will decrease the *brain-drain* to some extent. Prestige of a scientific

worker should be enhanced and respectable living and working conditions should be created. Improvements in the post-graduate system of education should be carried out, training of scientific personnel should be well-grounded and realized according to state demand.

A new type of two-level degree conferring system will be introduced. This will demand clarification and modernization of mechanisms operating the system. The objective is the extension of sovereignty and independence of universities and scientific organizations, in the meantime keeping control over the quality on the part of State. Existing Ph.D. curriculum will be enriched by an educational component becoming consistent with the third-level degree conferred abroad. The student who has successfully completed the curriculum and has defended the thesis will be conferred the Doctor's degree. After completing tasks set forth by Post-Doctorial curriculum the scientist will be conferred the degree of Doctor of Sciences. The main peculiarity of the new system is that universities and scientific organizations will be authorized to confer degrees. The State body for control over quality will be responsible for quality and independent examination.

Need for Modernizing Infrastructure Resources and Material-Technical Base in Science Sector

The current issue presupposes the creation of a database on expensive and exclusive equipment and facilities, scientific personnel. All the scientific organizations are to be certified. This process should be followed by realizing a targeted plan aimed at modernizing material-technical base. In the meantime, it is essential to create a united fundamental library net by introducing new service technologies in them. The creation of complexes for scientific analysis, information and consulting will be a significant step forward. In this respect it is expedient to transform the Armenian Centre for Scientific Technological Information (under the auspices of the Ministry of Trade and Economic Development) into a state science governing body. A united information net should be developed and it should be connected to the international net. A science publishing system should be reorganized maintaining criteria consistent with international standards and a legislative base should be provided for electronic publication.

Establishment of an Independent Science Expertise System

The establishment of a long-term productive system for scientific expertise is a primary issue to be settled. Foreign specialists should also be enrolled if it is necessary. In order to support the effectiveness of the mentioned system, it is expedient to develop, adopt and unconditionally implement corresponding criteria for the evaluation of scientific and technological activities. International models may serve as a ground. Initially this system will be supported by foreign funds.

Clarification of Science and Technology Development Priorities

There should be made certain precisions in scientific and technological priorities. It supposes the development of a new list of science-oriented priorities. Armenian studies as a factor of national strategy should be counted among the ranks of leading priorities. The definition of science development priorities should be realized in compliance with the following criteria:

- Issues of state strategic significance
- Long-term international research problems
- Availability of a scientific school representing the corresponding field or the possibility of founding them
- Problems conditioned by national security

The definition of priorities should be clearly stated and it should proceed from the above-mentioned criteria. In the meantime projects and themes should be developed in accordance with priorities. New funding mechanisms for innovation projects are to be cultivated.

Integration of Science and Education

The integration of science and education is essential for a competitive education, for promoting scientific reproduction and sustainable economic growth.

A special integration plan should be developed. This plan should be aimed at establishing university chairs and branches in centers of excellence, organizing Master's programs on a contractual base and student training. Criteria for research institutions should be developed and implemented and several outstanding universities should be transformed into research centers. Consequently, several scientific organizations should be attached to universities.

Commercialization of Scientific Results and their Export to Domestic and Foreign Markets

The commercialization of scientific results and the establishment of a national investment (innovation) system are also among the pressing issues. Efforts for exporting scientific results should be launched. With the aim of settling this problem the following steps should be realized:

[1] The definition of a commodity type of scientific results (including technologies)

[2] Legislative amendments for protecting intellectual property in accordance with international standards

[3] Establishment of a system for innovation activity and creation of productive implementing mechanisms of scientific results

[4] Supporting small- and medium-sized enterprises in scientific innovations sphere, establishment of a loan-donating system

[5] Establishment of scientific innovation centers (technical parks)

[6] Encouraging venture investments

[7] Insurance of innovation risk

[8] Enhancement of state activities for filing patents and selling them in foreign markets

[9] Transformation of a part of scientific organizations into innovation institutions with developed marketing and commercial base

The verall process of improvements should be accompanied by corresponding legislative amendments. Alongside with the improvements, a strategy plan for science development in Armenia should be launched.

APPENDIX VI

Science and Technology in Armenia: Toward a Knowledge-based Economy

Executive Summary of the Report by the U.S. National Research Council

Armenia has a long tradition of excellence in science, technology and education. During the Soviet Era, Armenian capabilities were oriented to a significant degree toward supporting the Soviet military-industrial complex. Research activities, particularly in physics, were well financed. Education in science and engineering received strong support. A number of industrial facilities operated throughout the country, providing goods for local consumption and for more distant markets within the Soviet Union. In the spring of 2000, EU leaders accepted the ambitious reform programme pertaining to the *Lisbon Strategy*. The goal of the programme was for Europe to become the most competitive and dynamic knowledge-based economic area in the world by 2010.

With the disintegration of the Soviet Union, Armenia became isolated from many of its markets, and exports rapidly declined. As the economy spiraled downward, the budgets for research and education plummeted. A major exodus of technical talent began. Although many research and education institutions and a few industrial facilities remain, their capabilities have eroded considerably. Many laboratories and much equipment are obsolete, with little hope of replacement. Funds to cover costs of experimental work are scarce, and the funds that are available are not always directed to activities with high potential to build research capacity and lead to economic development. Paying customers for the results of research products are few in number. While educational standards remain high, the infrastructure supporting students continues to decline, and the *brain drain* has resulted in a serious deficiency of practicing scientists in the twenty-five to forty age bracket.

Nevertheless, Armenian scientists who remained have persevered and have achieved impressive results despite severe financial limitations. Now more than ever, Science and Technology (S&T) are critically important to the future of Armenia. With few export sectors remaining from the Soviet Era beyond foodstuffs, alcoholic beverages, and precious and non-precious stones, Armenia's scientific manpower has become one of the country's strongest assets. From the scientific, economic, and political points of view, this asset should be nurtured and promoted to the fullest extent possible.

For the past decade, the international community has recognized Armenia's technical wherewithal and has provided substantial financial support for its maintenance, although the support is far from adequate to meet the demand. The International Science and Technology Center headquartered in Moscow has become the most important external source of funds for research, and the U.S. Civilian Research and

Development Foundation also plays a significant role in supporting research, both directly and through the National Foundation of Science and Advanced Technologies (NFSAT). Various projects supported by the World Bank, the European Bank for Reconstruction and Development, and bilateral assistance programs of a number of donors also have technology dimensions. As is well known, remittances from Armenians living abroad are important in financing small activities (e.g., tuition for university students), and their donations occasionally support large projects (e.g., road construction).

However, in the aggregate, programs supported by more than twenty donors, together with programs of the Armenian Government, are barely able to meet the subsistence-level payrolls of the science and engineering workforce. There are few funds for new activities that could eventually generate their own financial resources.

For Armenia to realize its science and technology potential, the following suggestions are offered:

- Strong Armenian Government leadership is needed, including a long-term budgetary commitment, for upgrading the S&T base. While the Armenian Government has set a reasonable target of devoting 3% of the total national budget to S&T, actual funding has been only about one-third of that level. This low level of support by the government has led to excessive dependence on foreign sources of funding for maintaining the nation's S&T capacity. Insistence by foreign funders on cost sharing by the Armenian Government should be considered as a means of encouraging it to fulfill its budget commitments.
- A government mechanism should be established and funded to jump-start small entrepreneurs interested in developing promising innovative ideas with good market potential. U.S. experience with Small Business Innovation Research programs, which are operated by a number of federal departments and agencies to provide grants to stimulate technological innovation in the private sector, might be helpful in this regard. The appropriate funding level for this program could reach US$10 million annually if the initial results are positive.
- A limited number of centers of excellence should be established through a competitive process to serve as focal points for research and for science services, with financial support from both Armenian and international sources. The cost of this program should reach a level of $10 million annually within several years.
- NFSAT is a model institution for the support of peer-reviewed research funding in Armenia and deserves a severalfold increase in its funding. Funding for new S&T programs such as those recommended in this report should be administered through NFSAT or organizations with comparable peer review processes.

- Armenian institutions of higher education should continue to modernize their structures and curricula and should make strong efforts to recruit young, foreign-educated faculty. A sustained program of visiting professorships would provide a useful mechanism for distinguished foreign faculty who could not only enrich curricular content but also contribute ideas on university organizational and administrative practices. In addition, selected laboratories for use by faculty and students in the universities should be upgraded.
- Center for the Advancement of Natural Discoveries using Light Emission (CANDLE) is an ambitious attempt to create a state-of-the art, next-generation facility with applications in a wide range of fields, from basic physics, chemistry, and biology to applied research in drug design, medical diagnostics, and environmental remediation. It should be supported through the next pre-construction phase of detailed engineering design and of testing the concept of manufacturing equipment in Armenia. This phase will require funding of up to $4 million over a two-year period.
- Efforts should be launched to improve the overall intellectual property rights system in Armenia, with particular attention to promoting better understanding among potential inventors of the importance of protecting intellectual property rights and of the procedures to obtain such protection. The intellectual property rights program of the International Science and Technology Center should be extended to serve Armenian institutes.

There have been a few successes in recent years. Private entrepreneurs in the information technology sector have developed an industry with annual export sales reported at $50 million. Also on the international scene, the Byurakan Observatory remains an important facility for optical astronomy. Modernization of the agricultural sector is leading to increased exports to countries of the former Soviet Union. Foreign students are paying substantial tuition to study at Armenian universities. Medical services are being offered to patients from nearby states as well as to Armenians. Small specialty companies are beginning to find niches in high-technology markets such as the production of fuel cells and the design and manufacture of circuit board components.

Areas that seem to offer promise for further development include the following:

- Information technology and particularly software development
- Semiconductors
- Infrared detectors
- Large single crystals
- Laser Technology and Light Detection and Ranging (LIDAR) systems

- Precision electromechanical instruments
- Analytical services for the pharmaceutical, food, and chemical industries using advanced systems such as nuclear magnetic resonance
- Specialty chemicals
- Specialty materials
- Specialty agricultural products and processing
- Nutraceuticals and functional foods
- Genetic testing and other clinical laboratory services
- Human clinical trials
- Regional health centers
- Geological consulting
- Earthquake engineering
- Mineral refining

But in all of these areas, successful economic development based on S&T will require more than merely identifying research and technologies that seem to have economic potential in more mature market economies. It will require building the value chains that have the capacity to finance, develop, and market those promising technologies in a manner that returns value to the Armenian economy.

The handful of successes to date and the long menu of areas of potential interest for the future are encouraging, as is the resourcefulness of Armenian scientists in establishing and maintaining linkages with the international scientific community despite enormous challenges. Yet there will continue to be great difficulty in developing an internationally competitive S&T base and commercially viable innovative businesses. Limited research funds are currently spread over too many institutes and too many programs, and those activities that are not making significant contributions to science or economic development should be abandoned. At the same time, steps must be taken to provide more opportunities for young scientists and engineers to assume responsible positions with adequate compensation within the universities and research institutes that command international respect. With reasonable funding and more focused and determined efforts in the areas highlighted in this report, Armenia should be able to move forward toward a viable knowledge-based economy.

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science policy studies

Towards a Science, Technology & Innovation Policy for the Republic of Armenia

This study examines the main features of science, technology and economic development in the Republic of Armenia and underlines the need for decision makers to take steps to ensure that S&T has a leading role in the national developmental strategies of the Armenian Government.

The author, Mr. Markku Markkula, discuses key components required to implement an effective innovation policy and provides recommendations encouraging the creation of a national innovation system that shifts towards a knowledge-based economy aiming to link science and technology development to the production sector.

This study was carried out within the framework of UNESCO's Medium-Term Strategic Programme Objective to foster policies and capacity-building in science, technology and innovation.

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