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## **Technology Foresight Panels**

Expert Papers

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## Fostering industrial development in *catching-up* countries<sup>1</sup>

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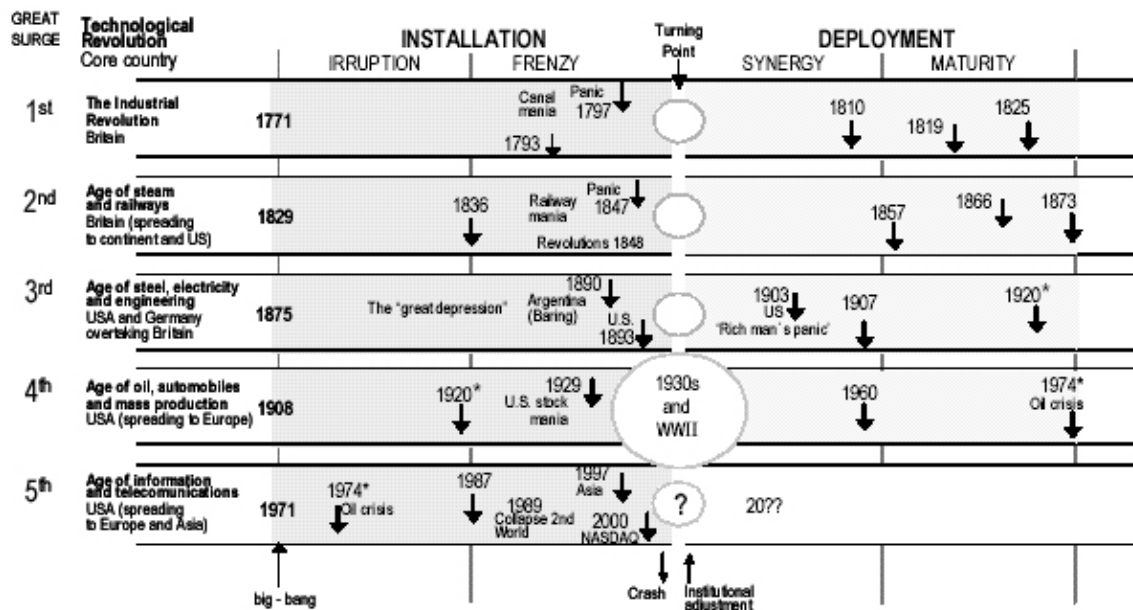
Technology Foresight Panel 6

### Techno-economic paradigms and the capitalist economic system

In the long perspective, no capitalist economy develops randomly or aimlessly; it develops towards gradually increasing productivity. However, this development is not linear but dynamic with sudden leaps – this is caused by an extensive use of new technology which has wide expansion potential and which triggers higher productivity, i.e. by the techno-economic paradigm.<sup>2</sup>

The history of economy shows that these paradigms have lasted for nearly half a century<sup>3</sup>, starting with explosive development in narrow fields of technology, until the technology becomes so cheap and offers a multitude of different applications, essentially allowing all branches of industry to sharply increase productivity. Increased productivity and the ensuing scale effect (production costs decrease as the output increases) do not result in an international price reduction, but rather in an extensive rise of wages.

**Figure. Five successive surges and major financial crises**



Source: Carlota Perez, *Technological Revolutions and Financial Capital. The Dynamics of Bubbles and Golden Ages*, 2002, Cheltenham - Northampton, MA: Edward Elgar Publishing

<sup>1</sup> Parts of this paper are based on the following publication: Marek Tiits, Rainer Kattel, Tarmo Kalvet, Rein Kaarli, Competitiveness of Estonian economy and future outlooks, forthcoming 2003, <http://www.tan.ee>

<sup>2</sup> Carlota Perez, *Technological Revolutions and Financial Capital. The Dynamics of Bubbles and Golden Ages*, 2002, Cheltenham - Northampton, MA: Edward Elgar Publishing

<sup>3</sup> This phenomenon was first observed in the capitalist economic system by Russian economist Nikolai Kondratjev in 1926. See also: Cris Freeman, Francisco Louçã, *As time goes by – From the Industrial Revolutions to the Information Revolution*, Oxford University Press 2001

Such technologies will presumably be those which allow an abrupt or even decisive improvement in productivity now and in the decades to come. When improved productivity, based on a certain technology, expands and penetrates other sectors and in turn improves productivity in those other sectors, it means a vigorous economic development.

However, the rapid spread of knowledge and technology, particularly in developed countries, means that productivity, relying on certain technology, cannot grow endlessly, and decreases inversely proportionally to the spread of technology, because competition toughens. In such a situation, a new technology and a new related paradigm can generate a new rise in productivity.

The current paradigm is based on information and communication technologies (ICT), meaning that the productivity growth is the greatest in ICT sector and it also gives spillovers into other sectors via introduction of ICT and inherent of it organisational and financial innovations.

ICT has just come through the financial capital lead installation period of extensive build-up of new infrastructures. In-line with the above theory, we can reasonably argue and that with the collapse of NASDAQ in 2000 and current global economic downturn, ICT paradigm has reached the turning point, but it is not over yet. Looking at the previous paradigms, we can expect some 20 years more of the deployment period of ICTs, where production capital assumes the leading role in socio-economic development.

### **Machines inside our cells - visions for 2020+**

The size of the 1<sup>st</sup> transistor invented 55 years ago was approx 10 million times of that of the first experimental single-molecule transistor described in *Nature* magazine in June 2002.<sup>4</sup> Recently, researchers at the University of Oklahoma have demonstrated that the 19 hydrogen atoms in a lone liquid crystal molecule can store at least 1024 bits of information.<sup>5</sup> These developments hold a promise of opening up development of completely new generations of data processing systems. It allows for explosion of all kinds of machine intelligence and gadgets, drastically diminishing in size.

In their report "*Orientations for WP2000 and beyond*"<sup>6</sup> on the future priorities for research and technological development, the Information Society Technologies Advisory Group (ISTAG) to the European Commission focuses on the concept of Ambient Intelligence, where humans are constantly surrounded by intelligent environment interfaces supported by computing and networking technology. Here, the three most important characteristics of this vision are: connected *always* and *everywhere*, the use of services is *enjoyable*.

It stems from the convergence of ubiquitous computing and communication, and intelligent user friendly interfaces. As the ISTAG vision is based to a large extent on the contributions by European leading researchers and industrial players. It is therefore not surprising to see, that various national foresight programmes and RTD programmes have identified very similar priorities.

Similar trends are foreseen by the famous inventor and future visionary Ray Kurzweil<sup>7</sup>. He writes: "By 2009, computers will disappear. Displays will be written directly onto our retinas by devices in our eyeglasses and contact lenses. In addition to virtual high-resolution displays, these intimate displays will provide full immersion

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<sup>4</sup> Peter Weiss, „Shrinking toward the Ultimate Transistor“, Science News, 10 August 2002

<sup>5</sup> Will Knight, „Digital image stored in single molecule“, New Scientist, 1 December 2002

<sup>6</sup> Scenarios for Ambient Intelligence in 2010, ISTAG 1999-2001, Seville JRC/IPTS

<sup>7</sup> Ray Kurzweil, *The Age of Spiritual Machines: When Computers Exceed Human Intelligence*, New York, Penguin Books

visual virtual reality. We will have connection ubiquitous, very-high-bandwidth wireless connection to the Internet at all times.”

Further, Kurzweil describes: “By 2029, as a result of continuing trends in miniaturization, computation, and communication, we will have billions of nanobots - intelligent robots the same of blood cells or smaller - travelling through the capillaries of our brain communicating directly with our biological neurons. By taking up positions next to every nerve fibre coming from all of our senses, the nanobots will provide full-immersion virtual reality involving all five of the senses.”

In the world, there is a growing recognition, that this is not plain science fiction writing, and there is a convergence of information, bio-, nano- and cognitive sciences emerging<sup>8</sup>. The above argument is most vividly also supported by a number of recent works of renowned think-tanks, like by RAND Corporation and others, commissioned by the U.S. National Science Foundation, Department of Commerce, etc.

Further to that, we already see several on-going research projects, which head in this direction. They aim at making nanotechnology implants doing things that nature simply can't: such as making drugs or generating electricity. This is not just loose speculation or an idle dream: it is work in progress at Cornell University and many other places around the world<sup>9</sup>.

Ian Sample reports in the New Scientist magazine: “Smart implants that deliver drugs precisely when they're needed are already near to hitting the market. Also on the way are electronic devices that tell cells to make specific hormones when your body needs them, and electricity generators that assemble themselves inside a cell and then tap into the cell's own energy source for the power to run. There is no question that machines are beginning to infiltrate the biological workings of life.

The first medical application of implantable nanotechnology is currently proving its worth in trials. Tejal Desai at the University of Illinois has developed a nano-engineered implant that could mean people with diabetes would no longer have to inject insulin.”<sup>10</sup>

Over the last 50 years, we have seen evolution of pacemaker technologies, as an accepted form of intrusion into human body. Recently, the U.S. Food and Drug Administration permitted the use of implantable ID chips in humans, providing they are used for “security, financial and personal identification or safety applications.”<sup>11</sup>

For beneficiaries, implant technologies involve possibly some future advantages, like rapid math, memory capacity or communication by thought.<sup>12</sup>

And here again, on-going *cyborg* projects, playing around with implants connecting human nervous system and a computer and thence to the Internet via bidirectional link, are the lively proof of fast developments in these areas.<sup>13</sup>

In Emory University in Atlanta, Philip Kennedy has implanted two stroke victims. In these experiments, it has

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<sup>8</sup> Brad Wieners, „Eight Technologies That Will Change the World“, Business 2.0, June 2009

<sup>9</sup> Ian Sample, „Small visions, grand designs“, New Scientist, 6 October 2001

<sup>10</sup> *Ibid.*

<sup>11</sup> „ID Chip's Contrivertial Approval“, Wired magazine, 23 Oct 2002

<sup>12</sup> The later is sometimes seen as something, which would enable to overcome the problems of very slow, inaccurate and often terribly erroneous analogue voice communications between the humans.

<sup>13</sup> Kevin Warwick, „Identity and Privacy Issues raised by Biomedical Implants“, IPTS Report no. 67 (2002), EC JRC, pp.29-34; See also <http://www.kevinwarwick.org/>

been possible to control a cursor on a computer screen using signals transmitted directly from the subject's brain. Hence, ideas have emerged, that electronic signals can also be transmitted out of the human brain to operate and interact with surrounding technology - the Ambient Intelligence.<sup>14</sup>

With these latest developments in implant technologies, a completely new set of issues, related to privacy, ethics and responsible conduct of science emerges. All of it leads us very close to the Kurzweil's existentialist question - how to distinguish between the human person and the machine - when your computer has become emotional, and displayed the following message on the screen: "I'm lonely and bored, please keep me company"<sup>15</sup>

This is pretty scary.

### **Implications for science, technology and innovation policies**

Today, ICT and biotechnology policies are radically different, because ICT has reached a phase where the development of pure technology is starting to diminish gradually, while the "real" use of ICT for economic purposes is only beginning. This means that the competitive advantage given by the development of IT as a technology is going to decrease gradually over the next ten to twenty years. A competitive advantage and higher productivity are given increasingly by the use of ICT as an economic activity across the economies.

Converging info-, bio-, nano- and cognitive sciences are likely to form the basis of the next techno-economic paradigm.<sup>16</sup> These technologies are still very much in the basic research phase, with rather limited economic effect in short term. While biotechnology has already a number of specific application areas like agriculture or biomedicine, most of the bio- and nanotechnology products today are essentially R&D products, enabling future RTD activities. Neither biotechnology nor nanotechnology products are *really* cheap and readily available for massive exploitation to improve the productivity throughout the economies yet.<sup>17</sup>

This means that R&D and innovation policies must be always built on a specific technology and its specific stage of development. Economic policy has to be targeting on development of specific technologies and economic clusters.<sup>18</sup>

When designing innovation strategies or public policies, one has to acknowledge, that in today's globalised world, multinational corporations provide 80% of private sector research and development expenditure, and they produce and control the majority of the world's high-tech solutions.<sup>19</sup> Therefore in-depth integration into global production networks and one's subsequent upgrading of competitive advantages is crucial.

For ICT industries, strategy and policy questions are increasingly related to the development and transformation of global production networks. With increasing number of ICT industries reaching their maturity phase, product development slows gradually down in these industries. The market is going to be dominated by more standardised products, offered by large companies under well-known brands. As manufacturing systems develop, production facilities are moved into regions with relatively lower labour costs.

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<sup>14</sup> *Ibid.*

<sup>15</sup> Ray Kurzweil (2000)

<sup>16</sup> This still educated guess at the best, as these expectations may not come reality as well. Here, one of the striking examples would be the history of development of nuclear technologies after World War II.

<sup>17</sup> Carlota Perez's report, which also discusses Estonia, at the seminar "How are ICT and Biotechnology Related? Policy Implications for Estonia", is available at <http://www.praxis.ee/innovation/workshop/>.

<sup>18</sup> Innovative Clusters: Drivers of National Innovation Systems, OECD, Paris 2001; Michael E. Porter, *The f Nations*, London: Macmillan, 1990.

<sup>19</sup> J. Dunning, *Multinational Enterprises and the Global Economy*. Workingham, England and Reading, Massachusetts, Addison Wesley, 1993, p. 290

If *catching-up* countries are about to benefit from ICTs, identification of more promising emerging industries, specialisation and rapid industry acquisition, clustering and in-depth integration into larger supra-national production networks should be thought. The same is true for mature biotechnology based industries, like biomedicine, where large multinationals dominate the market, and small newcomers are left no chance.

In emerging converging technologies, capability building i.e. establishment of world class higher education and public good research over the longer period of time is the key. Gradually, with the emergence of completely new info-, bio-, nano-, and cognitive sciences based industries; product development and design, ability move fast and sufficient availability of financial capital (especially risk funds) are going to become more important.<sup>20</sup>

### **Candidate countries response to the Lisbon strategy?**

As the part of realisation of the Lisbon Strategy, Barcelona Summit decided to increase investments into research and development in European Union up to 3% of GDP by 2010.

However, 3% investment from GDP into R&D is not target in itself. Especially for *catching-up* countries, it would be completely wrong to assume, that overnight most of innovation and economic development would start taking place, based on commercialisation of basic research conducted in public research institutions. This kind of obsolete linear model of innovation never works.<sup>21</sup>

The actual target is learning economy,<sup>22</sup> where entrepreneurs invest continuously into learning, into development of more advanced products, which ideally would be capable of commanding supreme prices at the world market. Universities and research institutes play of course important and ever increasing role in supply of public good research and quality human resources. Therefore, in all these developments, overall socio-economic environment shaped by the government and the society at large has important say.

Throughout the 1990s, series of economists have seen foreign direct investment lead technology transfer, gains in productivity increases, related organisational learning and spillovers into domestic enterprises, as the main engines of economic development in European *catching-up* countries.<sup>23</sup>

At the same time, continuing problems with the foreign trade balance in most of the CEEC, as well as widening income/productivity growth gap (at least in some of the countries in the region), put extra pressures to the macroeconomic stability. Therefore, success in taking up novel ICT solutions, praised by many, needs urgently to be translated into innovative industrial capabilities, and the real knowledge economy. In this, industrialisation strategies and the consecutive economic booms in Korea, Taiwan and Singapore or Ireland, serve a good examples offering a number of lessons.<sup>24</sup>

This kind of shift to the true innovation based economy, where domestic novel R&D results lead socio-economic development, does not happen spontaneously overnight. Economic development should be rather seen, as evolutionary process, where entrepreneurs gradually upgrade (or loose) their competitive advantages, compared to their competition next door or in another countries.

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<sup>20</sup> For evolution of industries, see for example: Michael Porter, *Competitive Strategy: Techniques for Analyzing Industries and Competitors*, New York: Free Press 1980

<sup>21</sup> See also: Charles W. Wessner, Sujai J. Shivakumar, „The role of Macro Targets and Micro Incentives in Europe’s R&D Policy“, IPTS Report No. 69, JRC/IPTS 2002

<sup>22</sup> Bengt-Åke Lundvall *et al*, *Globalising learning economy: Implications for innovation policy*, Report bcontributions from seven projects under the EC

<sup>23</sup> See for example: Slavo Radosevic, *Restructuring and Reintegration of Science and Technology Systems in nomic Forum*, p.1.2 *Economies in Transition*, 1996

In this process, government policies, incentives for technological upgrading (be they explicit or implicit), the international business environment, and good luck are all important shapers of the operating environment of enterprises and the competitiveness of enterprises depends on production factors, demand, strategic choices, cooperation and competitive environment (clustering)<sup>25</sup>.

Frequently cited low R&D investment, and weak collaboration between public research institutions and enterprises are only the symptoms, not the problem itself. Structural problems in (higher) education and public research systems, lack of competitive pressure for companies to innovate, and the availability of resources for long-term investment are the real problem. For many entrepreneurs, because of the above and a number of other reasons, investment into R&D carries simply too high risk.

At the same time, the large part of the industry of Estonia and other Central and Eastern European countries as well is already by its nature low-tech. In this context, the aspiration of increasing the private sector expenditure to the R&D activity to the same level with developed countries remains unachievable. The only possibility shall be total industrial restructuring including the movement towards the launching of the high technology within the low technology as well.

So far, the analysis of transition and developing countries conducted by UNIDO shows that only a few of them have managed to repeat Ireland's performance: to combine their reliance on foreign direct investment with a strong industrial policy while dealing purposefully with the areas in which they desire to enter the market, and developing skills necessary to that end. Most of the countries have applied far more passive foreign investment policies, benefiting from sound macro-economic equilibrium, business support, attractive location and good luck.

The less successful developing economies – and there are many – have not managed to implement any of these strategies properly.<sup>26</sup>

### **The role of foresight in responsible policy-making**

One should never forget that new technology always creates asymmetric markets and distribution of knowledge. Therefore, availability of world class (higher) education and public good research and the mechanisms for socialisation of risks, are clearly some of the most important prerequisites in the continuing *catching-up* process.

Falling into "tertiarisation trap", based on misinterpretation of globalisation trends and the increase of the share of service sector within the industrialised welfare economies after WWII should be avoided. Neither is the success of the Asian newly industrialised economies directly replicable, and the use "copy and paste" policy-making should be clearly avoided.

For the future economic development of the *catching-up* countries, establishing of strong industrial specialisation in the areas, where the needs of home market seem to precede the prospective future needs of incomparably larger international markets, or where competitive production facilities in high value added industries can be offered to the major global players, seems to be the strategy. In this process, R&D and innovation policies have to become much strong part of the broader structural agenda.<sup>27</sup>

For scientists, one of the most important challenges is making science and technology understandable for society.

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<sup>24</sup> Linsu Kim (ed), Richard Nelson (ed), *Technology, Learning and Innovation: Experiences of Newly Industrialising Economies*, Cambridge: Cambridge University Press 2000.

<sup>25</sup> Michael E. Porter, *Global Competitiveness Report 2002-2003*, World Economic Forum, p.1. 2

<sup>26</sup> UNIDO Industrial Development Report 2002/2003, <http://www.unido.org/idr/>.

<sup>27</sup> *Innovation Tomorrow. Innovation policy and the regulatory framework: Making innovation an integral part of the broader structural agenda*, Innovation papers no 28, DG Enterprise, European Commission 2002

It is vital to be able to communicate to the public efficiently all the consequences of possible actions (or inactions) to the future of the society.

The European Federation of National Academies of Sciences and Humanities (ALLEA) has formulated recommendations for reforming science and technology base, which are entirely applicable to most of the CEE/NIS region<sup>28</sup>:

- not only increasing the funding of research and development in general, but channelling it to the most prospective areas;
- not only introducing incentives for encouraging innovation *per se*, but creating foresight programmes, to develop the future vision with a broad consensus within the general public and formulating a National Development Plan<sup>29</sup> guided by this;
- not only introducing incentives for stimulating young people in research and development,, but estimating the long-term needs of manpower in academia and society
- not only stimulating individual peer-reviewed research and development , but creating the centres of excellence in research, and ensuring their participation in respective international clusters
- not only improving research infrastructures, but combining them with education and innovation

### **Comments by Kiril Boyanov**

on

Fostering Industrial Development in Catching-up Countries  
by Mark Tiits

In this paper, the techno-economic paradigms are described very well as well as their implications for science, technology and innovation policies.

The response of candidate countries to the Lisboa strategy is discussed. The role of foresight in responsible policy-making is given.

The paper is very interesting, the main ideas and the conclusions are clearly exposed. I am very pleased by the presentation and the content of the paper.

Some comments could be done:

The foresights about the development and the application of the nano technologies, built in the human body are too much dependent on the way of their acceptance from the social point of view and the public establishment. For example although the technology preconditions were available, the mass distribution of Internet was late for

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<sup>28</sup> European S&T Policy and the EU Enlargement. Workshop of experts from pre-accession CEC and f EUROPOLIS Project Group. Report, S. Anguelov and P. Lasserre, eds. UNESCO ROSTE, Venice, 2000

<sup>29</sup> For EU Candidate Countries it's a time of finalising National Development Plans for 2004-2006, which will be the bases for allocation of investment by EU structural funds.

a long period. We must not forget that the application of such technologies is also connected to long biological researches.

It is interesting to discuss the case when the next paradigm of the economic development (for example nano-technologies) will cover the present paradigm connected with the information technologies. In this case a continuation of the period of obtaining a competitive advantages from development of IT as a technology would be expected.

A crisis in the security of information exchange in Internet and necessity of creating another or transforming existent platform for global communications will have probably a similar effect. It will reflect more essentially on the economics of the catching-up countries.

The development of the ICT technologies in NAS is connected with the large differences in the economic of catching-up countries. To reach 3% for R&D by 2010 is a dream for some of them due to the low standart of life. The idea for giving prominence to education is absolutely in the right direction, but a mechanism must be found to stop or limit the brain drains, since otherwise the effect for some countries will be negative. Without the strategy for attracting of foreign investments in the field with R&D potential is critical. The question about the ways of synchronizing european programs with these of NAS to get similar or close effect to those in Irland, Korea and other countries would be interesting.

### **Comments of Niko Schlamberger**

**on**

Title: ICT foresights as the tool in fostering industrial development in the CEE

by Marek Tiits

Talking of CEE countries we must understand that those are countries in transition. It seems to be a faded issue ac the expression is among us for a decade or so and we all think that we understand what it is all about. However, things are not quite as simple as that. The countries are in a transition indeed, but this is a three-in-one transition: local, European, and global at the same time. The first one is a transition from a plan economy to marked-oriented one. The second is a transition from one-party ruled country to a democratic one that are welcome to the rest of European Union member states as new members. The third transition is that from a county of industrial society to a country of information society. All transitions are going on simultaneously and all must be completed successfully and in a rather short period. The experiment must be completed at the first try as no one can afford to try twice – there is neither time nor resources enough for more than one round.

The situation that we can observe shows that the EEC countries have successfully completed the first one and that they are next to the successful end of the second one. The last one is still in course, but the countries are there not alone as most of the countries even of the developed world is still in the same position. The transition process has been assisted by the rest sometimes even beyond expectations, but sometimes also regarded upon with a distance and even bewilderment. We should appreciate the former and carry no hard feelings for the latter

as transition is a process that only those that are undergoing it may understand. For the rest it is only more or less academic exercise.

- In the context of assistance in transitions such events as TSF are extremely valuable. They help to assess one's situation and compare it to the rest of peer countries and to the ones that are waiting for them to join. It is not altogether certain if the conference can enhance industrial development in CEE countries directly. What it may bring about is an understanding for the differences among economies and an understanding how to use them to the best advantage of all.