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TOWARDS MODERN STI POLICY-MAKING IN ESTONIA[1]

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Abstract. To send a man to the Moon, was the strong vision leading peaceful development of science and technology in the United States after WWII (Kennedy 1962). This article discusses if Estonian science, technology and innovation policy should be led by any longer-term clearly spelled out objectives, which would result in the consolidation of efforts in science, economy, and society at large. The author also aims to initiate a debate on what could be the bases for such a shared vision on Estonia's future.

Techno-economic paradigms and the development of capitalist economic system

Common wisdom, shared by the entrepreneurs and liberal policy-makers throughout the 1990s world-wide suggests that the development of capitalist economy under the free open market regimen is fully automatic; nevertheless specific scenarios for the future beyond 2–3 years are considered extremely difficult to predict.

However, all economic activities are not the same. There are some, which offer decreasing returns to the scale, and some which offer increasing returns, allowing this way for an improvement of living standards. One should never forget that new technology always creates asymmetric markets and distribution of knowledge. Specialisation pattern of the economy is therefore decisive for the future prosperity of the nation (Reinert 1999).

Also, a more thorough look into the history of economic development over the last few centuries convinces that in the long perspective, capitalist economy does not develop randomly or aimlessly; it develops towards gradually increasing productivity. This development is not linear but dynamic with sudden leaps, which are caused by an extensive use of new technology with wide expansion potential triggering higher productivity, i.e. by the techno-economic paradigms (Perez 2002).

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[1] The views of this article are solely those of the author and do not necessarily reflect the opinions or policies of the Government of the Republic of Estonia. Parts of this paper are based on: Tiits et al 2003.

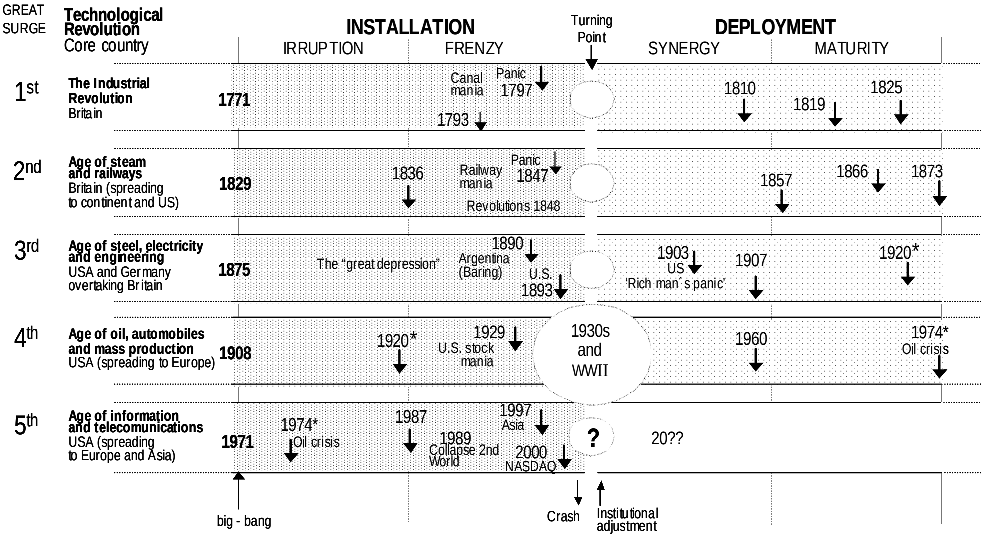
The history of economy shows that these paradigms have lasted for nearly half a century[2], starting with explosive development in narrow fields of technology, until the technology becomes so cheap and offers a multitude of different applications, essentially allowing all branches of industry to sharply 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.

Such technologies will presumably 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 in proportion 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 its inherent organisational and financial innovations.

Figure. Five successive techno-economic paradigms 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

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[2] This phenomenon was first observed in the capitalist economic system by Russian economist Nikolai Kondratjev in 1926. See also: Freeman and Louçã 2002

ICT has just come through the financial capital led installation period of extensive build-up of new infrastructures. In line with the above theory, we can reasonably argue that with the collapse of NASDAQ in 2000, and the 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 more years 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 1st transistor invented 55 years ago was approximately 10 million times of that of the first experimental single-molecule transistor described in *Nature* magazine in June 2002 (Weiss 2002). 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 (Knight 2002). These developments hold a promise of opening up a development of completely new generations of data processing systems. It allows for the explosion of all kinds of machine intelligence and gadgets, drastically diminishing in size.

In their report “*Orientations for WP2000 and beyond*” (ISTAG 2000) 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. The ISTAG vision is based to a large extent on the contributions by European leading researchers and industrial players. It is not therefore surprising to see that various national foresight programmes and RTD programmes have identified very similar priorities.

Trends like that are foreseen by the famous inventor and future visionary Ray Kurzweil. 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 into visual virtual reality. We will have ubiquitous, very-high-bandwidth wireless connection to the Internet at all times.” (Kurzweil 2000)

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.”

There is a growing recognition in the world that this is not plain science fiction writing, and there is a trend for convergence of information, bio-, nano- and cognitive sciences emerging (Wieners 2002). The above argument is most vividly also supported by a number of recent works of renowned think-tanks, like by RAND Corporation (Anton et al 2001) and others, commissioned by the U.S. National Science Foundation, Department of Commerce, etc. (Roco et al 2002).

But there is even more to the fact that 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. We see several already on-going research projects, which head in this direction. They aim at making nanotechnology implants doing things that nature simply cannot: such as making drugs or generating electricity (Sample 2001).

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.” (Sample 2001)

Over the last 50 years, we have seen the evolution of pacemaker technologies as an accepted form of intrusion into the 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.” (Scheeres 2002)

For beneficiaries, implant technologies involve possibly some future advantages, like rapid math, memory capacity or communication by thought.[3]

And here again, the 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[4] (Warwick 2002)

In Emory University in Atlanta, Philip Kennedy has implanted two stroke victims. In these experiments, it has been possible to control a cursor on a computer screen using signals transmitted directly from the subject’s brain. It has hence transpired that electronic signals can also be transmitted out of the human brain to operate and interact with surrounding technology – the Ambient Intelligence (Warwick 2002).

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[3] 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.

[4] See also http://www.kevinwarwick.org/

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 takes 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 (on your retina): "I'm lonely and bored, please keep me company". Kurzweil (2000)

This is pretty scary.

Responsible conduct of science is therefore crucial. Also for a nation, maintaining minimal level of scientific knowledge in all emerging areas of science and technology is absolutely vital to be able to comprehend the latest developments, to advance in socio-economic development, and to be able to defend itself against previously unimaginable threats, should it become necessary.

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.[5] 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, establishing knowledge base for the 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.[6]

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 specific technologies and development of economic clusters (OECD 2001 and Porter 1990).

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[5] This is still an educated guess at the best, as these expectations may prove all faulty. Here, one of the striking contra-examples would be the history of development of nuclear technologies and related expectations after World War II. Nevertheless, following the above convergence hypothesis seems to be the only strong policy option, as compared to doing nothing at all.

[6] 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/.

For ICT industries, strategy and policy questions are increasingly related to the development and transformation of global production networks. With the increasing number of ICT industries reaching their maturity phase, product development gradually slows 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.

Therefore, when designing innovation strategies or public policies it has to be acknowledged 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 (Dunning 1993). In-depth integration into global production networks and one's subsequent upgrading of competitive advantages is therefore crucial.

If *catching-up* countries, like Estonia, 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 considered. The same is true for mature biotechnology based industries, like biomedicine, where large multinationals dominate the market, and smaller newcomers have no chance.

In emerging converging technologies, capability building, i.e. the establishment of world- class higher education and public good research over the longer period of time is crucial for economic development. Gradually, with the emergence of completely new info-, bio-, nano-, and cognitive sciences based industries, product development and design, the ability to move fast and sufficient availability of financial capital (especially risk funds) are going to become more important (Porter 1980).

Candidate countries' response to the Lisbon strategy?

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

However, investing 3% of GDP into R&D is not the target in itself. Especially for *catching-up* countries, it would be completely wrong to assume that most of innovation and economic development would start taking place overnight, based on commercialisation of earlier basic research conducted in public research institutions. This kind of obsolete linear model of innovation never works (Wessner and Shivakumar 2002).

The actual target is learning economy, where entrepreneurs invest continuously into learning, into development of more advanced products, and ideally are capable of commanding supreme prices at the world market (Lundvall and Boras 1997). In this process, the universities and research institutes play of course an important and ever increasing role in the supply of public good research and quality human resources. The government has necessarily a significant say in all these developments and therefore, even if neglected, in shaping the overall socio-economic environment of the nation.

Throughout the 1990s, a number 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 *catching-up* process in the European Union candidate countries (Radosevic 1999).

At the same time, continuing problems with maintaining a balance of the current account 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, the success in taking up novel ICT solutions, as any other foreign technologies, praised by many, needs urgently to be translated into innovative industrial capabilities, and the real knowledge economy.

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

In this process, the government policies (be they explicit or implicit), incentives for technological upgrading, 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, co-operation and competitive environment (clustering) (Porter 2002).

Frequently cited low R&D investment and weak collaboration between public research institutions and enterprises are only the symptoms, but not the problem itself. Structural problems in (higher) education and public research systems, the lack of competitive pressure for companies to innovate, and scarce competence available to 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 a risk.

At the same time, a large part of the industry in Central and East European countries, especially the Baltic states, is already by its nature low-tech (Havlik 2002). In this context, for the coming years, the aspiration of the increase of private sector investment into the R&D to the same level with developed countries remains unachievable.

The only possibility shall be total industrial restructuring including the movement towards the launching of high technology within the low technology as well. Here, industrialisation strategies and the consecutive economic booms in Korea, Taiwan and Singapore, Ireland and Finland, serve as good examples offering a number of lessons (Kim and Nelson 2000).

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 (UNIDO 2002).

Implications for Estonia

If specialisation in being poor and underpaid in the global division of labour is not the aim, availability of world class (higher) education and public good research, and the adequate mechanisms for socialisation of risks, are clearly the most important prerequisites for the continued *catching-up* process (Reinert 1999).

Falling further into "tertiarisation trap", based on misinterpretation of globalisation trends of the 2nd half of the 20th century, can only lead into poverty. The increase of the share of service sector within the industrialised welfare economies and moving the production out to the cheaper locations, while keeping strategic R&D activities at home base, does not mean that the role of competitive industries in improving the quality of life is diminishing.

Therefore, for the future economic development of a *caching-up* country, establishing strong scientific and 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, is essential. In this process, science, technology and innovation policies have to become a much stronger part of the broader structural agenda (EC 2002).

Overall, the global context has changed radically, and the success stories of Finland, Ireland and the Asian newly industrialised economies in the 1990s are not directly replicable. Therefore, the use of "copy and paste" policy-making should be clearly avoided. For Estonia, the dual strategy of acquisition of medium- and high-tech industries by means of continued FDI-led inward technology transfer, and simultaneous building up of national competence bases for the future indigenous high-tech industries seems to be the only viable option available.

In 2000, innovation investment of Estonian enterprises totalled a sizeable 2 billion kroons, whereas the majority of this investment was spent on the acquisition of machinery and equipment, and the related organisational changes (Kurik et al 2002). In this context, general innovation awareness incentives, encouraging innovation per se, are of relatively little relevance. It is much more important to provide proper, quality life-long learning at all levels of education.

It is also very clear that the funding of basic research has to increase sharply and the upgrade of the university infrastructures is desperately needed. However, in planning these investments, speculative exploitation of popular buzzwords, like "innovation", has to be avoided. Instead, serious planning work is needed to be able to achieve synergies from combining scarce resources available for upgrading the quality of education, research and innovation.

For public policy, it is a major challenge to accept that the state has a role in economic development, and the government has its influence even if this is neglected for one reason or another. Creating foresight programmes in order to develop shared visions of future, supported by a broad consensus of the general public and formulating a national competitiveness strategy guided from the above, is a tremendous challenge.

For scientists, one of the most important challenges is to make science and technology understandable for society, and to connect it with the future needs of the socio-economic development. It is vital to be able to communicate efficiently to the public all the consequences of possible actions (or inactions) to the future of the society.

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