Made in Estonia

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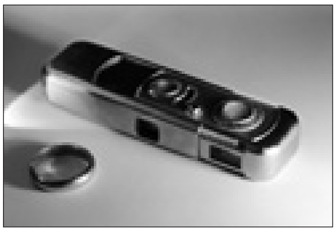

Front cover depicts the famous Minox camera by Walter Zapp.

Walter Zapp was born on 4th September 1905 in Riga.
In the 1920s, when he was already living in Estonia, Walter Zapp became fascinated with the idea of developing a small precision camera that would produce pictures with no lesser quality than the considerably bigger cameras. A decade later, in 1936 the first Minox camera prototype was ready. Unfortunately, no producer in Estonia was interested in his invention, and thus the series manufacture was launched in Riga.

Walter Zapp later wrote the following about the birth of Minox: “It is by far not enough to just have an idea, because its realisation takes a whole set of favourable conditions to be provided by the environment and the contemporaries. I am much indebted to Estonia for these favourable conditions.”

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Institute of Baltic Studies
Tartu 2006

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Institute of Baltic Studies (IBS) is an independent non-profit research and development centre that aims to assist the development of public policy in the Baltic Sea area by providing high-quality socio-economic analysis.

PRAXIS Center for Policy Studies is an independent non-profit think tank that aims to contribute to better public policy making process and to enhance general participation in public debate. PRAXIS offers innovative and high-quality analysis, studies and enhanced public participation to help identify and tackle key problems in the society.

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Introduction

The 1990s have cetainly been very progressive for Estonia that is now a member of the European Union and NATO, and rather successful for many of its active citizens. At the same time, in today's Estonia it is increasingly difficult for an entrepreneur to find qualified labour force and to remain compeitive on the basis of its existing advantages. Political rhetorics that follows the *Lisbon strategy*[1] of the European Union aspires for large-scale private sector inestments into research and development. These ambitions, however, seem to exceed our capacity. Constant level of record high current account deficit is endangering the economic stability. This all compels Estonia to pay ever more attention to next generation policies that would ensure not only the stability of business environment, but would also provide the premises for successful long-term development.

What kind of long-term investments would be most beneficial for the entrepreneurs in Estonia? What should the government do to secure growth in the real income of its citizens and in the export capacity of its enterpreneurs? What kind of policies should public sector follow in order to enable the enterpreneurs to employ business strategies that are not based on cheap labour and natural resources like they have been so far? What choices are there for a small transition country like Estonia that cannot afford major investments into multiple sectors? While thinking about future it is always useful to look back into the history.

There are surprisingly many similarities between Estonia's developments in the past decade and those of the young republic of the 1920s. While in excile Karl Selter analysed Estonia's experiences and perspectives for rebuilding the economy once independence is regained. He observed: *"Industry can be of support to advanced agruculture. Growth of industry and towns and increase in the total sum of salaries in industry is a vital footing that the rise of our agriculture should be based on. As bizarre as it seems, policital circles of independent Estonia did not comprehend this link between industry and agriculture. Some politicians had an unfriendly standing towards industry, others were permissive, but none of the parties adopted the enlargement of industry as a goal of their programme. The reason for such attitude may have resided in the fact that the majority of big industry was owned by citizens of non-Estonian descent, and their concerns remained distant to the wider population."*[2]

It is preceisly the advances in industry that created the preconditions for the expansion of service sector and for the development of rural life as well as for the increase in the living standard of the whole society. Although the future outlook presented in this book is clearly centered on technological development, industry and economic competitiveness, by no means do the authors consider a discussion on the development of a broader environment and society of any less importance. Progress in Estonia is, of course, not merely dependent upon the advances in industry or the investments in education, research and technology development; social policy, labour market development, competition, environment and rural policies – in other words, the functioning of the state as such – are equally important.

But should we prefer one or another type of investment, institution, strategy, policy, and on what grounds? This book draws on two assumptions: first, it is the task of public policy to decide between various options, and secondly, these decisions must be based on a solid analysis of existing circumastances and needs. Lack of a clear long-term target and the painfulness of structural changes that the society has to deal with are, however, among the major reasons why the efforts to develop knowledge-based economy have not resulted in much progress despite all the talk in Estonia as well as Europe.

Today Estonia still does not, regrettably, have a consistent, truely forward-looking long-term development strategy. A broadly accepted strategy of this sort cannot emerge from behind government's closed doors. Hence, the following analysis also aims at posing some questions that require serious deliberation and discussion in our society rather than trying to offer any ultimate solutions.

[1] "A new start for the Lisbon Strategy", European Commission, http://europa.eu.int/growthandjobs/index_en.htm.

[2] Karl Selter (1898-1958) was Minister of Economic Affairs of the Republic of Estonia in the years 1933-1938. He was charged with drafting both the smallest ever national budget in the crisis years of 1934/35 as well as the nearly biggest budget of the first Republic of Estonia in 1938/39. See also Karl Selter, "Eesti ülesehitamise probleeme" ("Problems in rebuilding Estonia"), *Korporatsioon Vironia 1900-2000, manuscript.*.

Executive summary

Starting with the rise of the city states of Italian renaissance and the 16th-17th century Dutch and German towns the concept as well as the social and economic success of modern state has been based on geographic boundaries. These boundaries are the very element that facilitate the process of specialisation or the emergence of welfare raising economic clusters. Then again, economic theory has essentially always followed Adam Smith's famous principle of the positive link between welfare and market size since bigger market is supposed to allow for more specialisation and, thereby, for growth in productivity and standard of living.

Rapid evolution of information and communication technologies as well as liberalisation of markets over the past decades have significantly changed the meaning and role of geography and proximity of destination markets in the socio-economic development. Value chains of global economy are no more shaped by geographic borders. Instead, they are increasingly formed within the boundaries of specific industries. Simultaneously, more and more economic units are established and relocated into countries and regions with most favourable socio-economic conditions for the respective stage in production. This means that the more basic production functions move into areas with cheaper labour force and relatively higher productivity, while the more complex and costly parts of development process remain in countries with higher standard of living. The situation is most problematic for those areas that can offer neither knowledge-based development activites nor cheaper skilled labour force with relatively higher productivity levels.

It follows from previous that the enhancement of the competitiveness of local companies as well as the choice of location for foreign investments is progressively more tied to specific economic and technology sectors. Diminishing opportunities for treating different economic sectors and technologies on equal grounds complicate not only the formulation of business strategies. Likewise, the development of policies and strategies that facilitate economic growth has become even more intricate. At the same time it is clear that in a race for generating more and more value-adding technologies a (small) developing state can only hope to be successful if it constantly and vigorously modernises its economy.[3]

Estonia's socio-economic development in the open global economy is by no means "a zero sum game" with its main focus limited to internal redistribution of revenues or determining the level of tax burden. As a member of the European Union, Estonian is in a completely different economic and political environment. Expected economic convergence will now replace the previous process of fairly technical adoption of *acquis communitaire* with a much more significant role for Estonia's actual specialisation on the common market and for the introduction of a supporting development strategy.

In which direction might Estonia's role in the changing international distribution of labour move in the coming decade? Social (or economic) changes do not happen overnight. This means that the developments in the past decade offer pretty good insights into how and which kind of technological structure Estonia's economy will evolve towards in the coming 5-10 years. Analysis of Estonia's past development shows that the technological structure of industry is not growing more knowledge intensive and complex, quite the opposite – distribution of labour is decreasing, so is specialisation, skills and quantity of skilled labour force; capacity to exploit new and emerging technologies is also on decline. While Western Europe competes with USA and the newly industrialised countries of South-East Asia in terms of their income, labour productivity, and knowledge and technology intensity of economy, it is China, India, Latin American countries and Russia that are the primary economic rivals to the new member states of the European Union.

A look at the data on export structure and industrial competitiveness reveals that Estonia is currently almost entirely specialised on wood processing activities (incl. furniture, printing and paper industries). Second position in the structure of exports is occupied by certain low value-adding functions of Scandinavian

[3] Since the publication of David Ricardo's work it has been widely accepted that it is only rational for an entrepreneur operating in a specific location to primarily focus on those sectors for which the existing environment offers at least some sort of advantages. Contemporary economic treatises do not, however, see these advantages as occurring by themselves. Instead, the entrepreneurial environment established by the government has a decisive role in the emergence of specialisations. See i.e. Charles King, *The British Merchant or Commerce Preserv'd,* London, John Darby, 1721; David Ricardo, *The Principles of Political Economy and Taxation*, London: John Murray, [1817] 1821; Paul M. Romer, „Increasing Returns and Long-Run Growth", *Journal of Political Economy*, 1986, 94, 5 (October 1986), 1002-1037; Francis Fukuyama, *State Building: Governnance and World Order in the Twenty-first Century*, Profile Books 2004.

infromation technology and electronics clusters. Over the past 10 years Estonia's rapidly developing wood processing sectors that belong in the Scandinavian wood cluster have become the most important sources of productivity (and thereby also income) growth in Estonia's economy.

Existing, relatively low-technology based structure of Estonia's economy can bring no automatic resolutions for the future nor direct the creation of new knowledge and ideas. It is equally unrealistic to attempt at reconstructing the Soviet time light industry, machinery and other sectors of industry that are nowadays extremely labour and capital intensive. Instead, Estonia should focus on modernising its currently rather efficient resource and low-technology based sectors, on the one hand, and, at the same time, expand its presence in the new generation of high and medium technology sectors starting with the value chains of information, bio- and nanotechnologies. The process of cultivating these new high-technology sectors must be properly intertwined with the existing structure and sepcialisation of Estonian economy. Otherwise the actual contribution of the new high-technology sectors to the growth of Estonia's standard of living will remain moderate despite the success of individual companies.

In the 1990s Estonian economy has gone through major structural changes and has seen a reduction in the number of jobs resulting from technological innovation. Nearly all sectors of industry (besides wood processing) have faced decline in employment and increase in social stratification that usually accompany technological and organisational advances. Too many poor people, however, can never be good for a country either in social or economic terms. This was noted already by Adam Smith in his *Wealth of Nations*.[4]

Creation of new jobs is, however, directly dependent upon the compatibility of existing skills and knowledge base as well as those offered by the educational and research system with the technological developments in the wider world and with the future structural changes in Estonia's economy. According to this logic the policies for modernising industry, educational and research system should, on the one hand, be sector specific. At the same time, they must also be very well coordinated in regard to each other. Establishing an effective system of vocational and continuing education and retraining as well as increasing funding for research and development are of equally critical value to the process of creating new jobs. Even so, none of these elements alone is able to bring about the structural changes needed in the society in order to shift towards knowledge-based economy.

Striving towards increased standard of living Estonia basically has to solve one of the core issues of development economics: how to make sure that the system for coordinating public and private sector investments take much better account of the global trends and long-term visions for Estonia's future than it has so far.[5]

4 Adam Smith, *The Wealth of Nations,* London, Campbell, [1776] 1991, Book I, VIII; American economist Arthur Okun noticed in his analysis of empirical data from 1960s that there was a virtually linear relation between the change in employment rates and real growth of economy expressed as gross national income (gross national product, GNP). A simple *Okun's law* based calculation shows that decreasing the number of unemployed in Estonia by roughly half (i.e. from the 2003 level of 10% down to 5%) would lead to a 15% increase in the gross national income. Measured in Estonia's 2003 indicators this would have meant nearly 16 billion EEK. See Arthur M. Okun, *"Potential GNP: Its Measurement and Significance",* American Statistical Association, Proceedings of the Business and Economics Section, 1962, 98-103.

5 See Ragnar Nurkse, „Some international aspects of the problem of ecomic development", *The American Economic Review*, 42, 2, May 1952, 571-583.

1. Foundations of knowledge-based economic policy

1.1. Competitiveness and the structure of industry

Antonio Serra from Naples is apparently one of the first researchers to give an extensive explanation of the foundations of economic development. It is worth noting that even the title of his work published in 1613 is close in concept to what Estonia is interested in today: *A brief overview of reasons that may bring a lot of gold and silver to kingdoms where there are no mines*.[6] How to secure welfare in a state that is small and does not have essential natural resources?

In slash and burn agriculture, even today's simplest Estonian horticulturist would be a great monopolist with an extremely large profit margin. With modern technologies, today's Estonian wood processors and clothing industries would have been very prosperous just one or a few centuries ago, but now they have to lay off more and more employees in the name of survival, which, in turn, creates new social problems. It is easy to predict that growing potatoes and sawing timber can be done in almost all countries of the world — we are on a perfectly competitive market where the primary components of competitive advantage are the relatively inexpensive labour and other production inputs, including natural resources.

Just like Serra, John Stuart Mill[7], a classic liberal, and several other economists have also shown that agriculture (and service sector) can only flourish in a country that has a successful industry. The reasons are simple: **economic activities are not alike in terms of quality, and their quality decreases in time. In industry, just like in certain knowledge-intensive services, it is possible to achieve such returns to scale that are difficult or impossible to compete with in other sectors of economy.**[8]

The quality of economic activity or the possibility to receive income from it depends on its intensity in terms of knowledge, technology and skills. This gives rise to dynamic competition the primary characteristic of which is the asymmetry of market. In simple terms, this means that competing entrepreneurs do not know exactly how one or the other generates its product. This (partial) lack of information on the competitor's side gives a manufacturer its competitive advantage — he can penetrate larger markets and even achieve a monopoly status in certain markets or market segments for a limited period of time. This, in turn, allows him to dictate high prices on the market (since they are not determined by competition).[9]

Therefore, in the long term, economy does not develop aimlessly in a random direction, but moves step by step towards increasing productivity or economic activities with higher levels of quality. Growing economic competitiveness is, however, not only about creating the so-called high-technology sectors, but also about utilising the specific competitive advantages of that country and its economy, and about continued renewal of its existing industry.

Milk can be produced "manually" at a farmhouse, but when there is a dairy factory within the distance of 10 km, we can be quite sure that the farmhouse has no chance of being competitive, unless the local people are extremely environmentally sensitive or there are massive subsidies granted. At the same time, dairy industry has been the one sector with the largest productivity growth in the post-war Europe. A simple survey proves, however, that it is not the dairy producers, but the companies that manufacture dairy processing equipment that are the wealthiest. In fact, the better part of profits from the technological renewal in the dairy industry goes to technology manufacturers instead of dairy producers. Dairy producers compete on a highly competitive market, because milk itself is not a scarce resource and this is what makes producers

6 Antonio Serra, *Breve trattato delle cause che possono far abbondare li regni d'oro e argento dove non sono miniere,* Naples, Lazzaro Scoriggio, 1613; Sophus A. Reinert, Erik S. Reinert, „Early National Innovation System: The Case of Antonio Serra's 1613 *Breve Trattato*", *Institutions and Economic Development/Istituzioni e Sviluppo Economico*, 1, 3, 2003.

7 John Stuart Mill, *Principles of Political Economy,* Oxford, Oxford University Press, [1848] 1998; Charles King, *The British Merchant or Commerce Preserv'd,* London, John Darby, 1721.

8 Erik S. Reinert, „The Role of the State in Economic Growth", *Journal of Economic Studies*, 1999, 26, 4/5, 268-326.

9 This is the reason why the competition policies of both USA and the European Union that are otherwise extremely hostile to cartels still protect the companies that have today achieved a short-term monopoly status on the market via research and development. Without such protection of intellectual property, there would be no development. At the same time, no entrepreneur would want to rely on mere expectations that its competitors would agree to respect each other's intellectual property simply out of good will. This kind of respect can be enforced only by the state. In other words, the state motivates, via the protection of intellectual property, entrepreneurs to take on very high risks (product that is being developed might prove to be bad or unsuitable for consumers, etc) in order to engender as many companies as possible that have significant market power and competitive advantages.

increase their productivity. Since competition on this market is fierce, milk producers cannot "extract" income from the increased productivity by imposing higher prices on the market; instead, they have to cut costs and reduce prices.

This rationale is explicable by experience rather than theory: technological development that takes place in manufacturing industry leads to higher income; technological development in service sector and agriculture, on the other hand, leads to lower prices. An important reason for this phenomen lies in the fact that in services and agricultural sectors technological advances are merely one of the inputs (in the form of new production equipment) that provides a competitive advantage just for a very limited time since the same input is easily available to other competitors. In industry, however, this very same technological solution is usually well protected by various means like patents, for instance, as the most typical protection mechanisms. Services and agricultural sectors are therefore characterised by fierce price competition, which, in turn, compels the developed countries to provide very high subsidies to their agricultural sectors.

Competition in industry, on the other hand, is significantly more dynamic and competitive advantages are much more profound in nature since they call for the presence of intensive development activities, broad educational basis, close interaction with and connections to subcontractors etc. In other words, while industry needs extensive specialisation or division of labour for its own development purposes, it simultaneously facilitates this process. If there is no suitable environment for industry to engender new value-added sub-elements (because, for example, there are not enough well-educated engineers) then industry itself will not evolve. This abstract industry might be very efficient and display vast export volumes, but in a situation like this it has become a mere link in the value-adding chain of some foreign cluster.

Since continued distribution of labour is also a precondition for further progress and since products can be protected against competitors, then competition in industry will not head towards price competition. Instead, it often shifts towards the opposite direction of so-called pay competition where progress provides opportunity as well as need to pay higher salaries to employees. Presence or emergence of a sufficient amount of such clustered industries will then lead to an overall rise in living standards. On the theoretical level economics has nearly always considered further distribution of labour as a source of economic growth.

Technological foundations of industry are in a constant state of evolution. This means that the economic characteristics of a certain technology change in time – a distinction is commonly made between high, medium and low technology in order to express this change of technology in time. The lower the level of technology the more important price competition becomes and the other way round: the higher the level of technology the more important are environment, education, development or, in other words, pay competition.

Based on the above, two observations are particularly important for Estonia:

1) Renewal of existing industry takes place on account of and through high technology, and it is in high-technology sectors where a large part of innovative profit (which is very large indeed) remains. Thus, if the renewal of existing industry is supported by high-technology sectors of the same country, a cluster-creating **virtuous circle** emerges where both existing industry and high-technology sectors earn more money. This, in turn, leads to an increased standard of living. If high technology, however, enters exploitation cycle via import, then it is the living standard of the exporting country that increases most. Traditional industries of the importing country become, indeed, more efficient, but not very sustainable, since the positive effect lies in the reduction of costs (for example, on account of labour force), which does not support an increase in the living standards of that country.

   This is a typical development path that developing countries have been experiencing over the past twenty years with economic growth derived from one or two sectors that are usually intensive on either natural resource or low-cost labour, and, thus, no wide-scale increase in living standard is achieved.[10] China, India, Taiwan, also Korea constitute a set of exceptions to this patter. These countries often just

10 See, for instance, Vladimir Tikhomirov, „The 2nd Collapse of the Soviet Economy: Myths and Realities of the Russian Reform", *Europe-Asia Studies*, 52, 2, 2000, 207-236; and Mario Cimoli and Marina Della Giusta, "A New Dualism Dimension in Processes of Economic Development: Loyalty or Voice for Latin America?", Paper prepared for the Conference of the European Association for Evolutionary Political Economy "Comparing Economic Institutions", Siena, Italy 8 – 11th November 2001, manuscript.

"ignore" the regulations of free market and copyright protection. However, this type of policy is becoming increasingly impossible in the world of globalising trade.[11]

2) The lower the technological level of existing industry the tighter, nearly perfect, is competition on the market where this industry operates. All companies have essentially the same technology and knowledge base and no one can afford the extra costs of research and technology development. This leads to a situation where there is influx of modern (high) technology via import, and industry is, indeed, somewhat more efficient, but the living standard in the country hardly ever increases. The share of such low technology based industry is large in Estonia and a number of other Central and Eastern European countries.[12]

   The general level of knowledge base (education, science) in countries with mostly low technology industry is usually also similar, i.e. rather weak. This means that domestic capacity to renew existing industry is low, too. If an effort is made to cultivate a modern high technology sector (for example, information technology or biotechnology etc) in a country like this, then the primary market for that sector is inevitably a foreign market. Although it is very beneficial to that particular high technology sector, it does not have much impact on the general economic development of the country. Unless strong domestic virtuous circles are created between the existing industry and a new high technology sector (for example, IT and biotechnology), it is essentially a state of simple export of the main "natural resource" of the 21st century – the brains – with no increase in the living standard of that country resulting from it.

These policies for modernising the structure of economy (i.e. industrial policy) are found not only among the historical and contemporary policies of all developed countries. They are just as much present in the postulates of *Self-Governing Estonia* (*Isemajandav Eesti* - IME) that was once enacted as a law, and thus makes them as valid in today's legal framework. IME document was instigated in 1987 by Siim Kallas, Tiit Made, Edgar Savisaar and Mikk Titma in a yearning for independence from the Soviet Union, and it advocated the principles of modern market economy.[13] Besides the introduction of national currency, IME document also postulated the vital goal of prioritising the development of high technology and knowledge and skills intensive sectors of production, quite the same way that all today's developed countries once got engaged in systematic cultivation of skills intensive sectors of production. These views resemble the policies systematically pursued by the European Union in its implementation of the Lisbon strategy and establishment of new innovation and industrial policies for the enlarged Europe.[14] Evidently these must be the universal principles of economic policy.

It is not the least surprising that the European Union assigned Estonia the task to develop and start implementing a coherent industrial policy already before the accession: *"There is still a need to complete the development of a comprehensive industrial policy, and to define and implement specific measures in this framework. Estonia should continue its efforts and set clear priorities in collaboration with the business community, the financial sector and other relevant stakeholders."*[15] Since this policy belongs to the domain where the European Union's competence is limited to the open method of coordination and main responsibility for devising and implementing policies rests with the member countries, the absence of such policies did not hinder Estonia's becoming a member of the European Union. The only problem lies in the fact that without this policy and with the continuation of current specialisation trends, Estonia is unlikely to ever catch up with the level of economic development in the European Union, the US or the "Asian Tigers".[16]

11 For further reading, see Sanjaya Lall, „Industrial success and failure in a globalized world", 2003, manuscript.

12 Peter Havlik, *Productivity Catch-up and Export Specialisation in CEE Manufacturing Industry*, WIIW, May 2001.

13 See the Act "Principles of Self-Governing Estonia", ÜVT 1989, 18, 223, http://seadus.ibs.ee/aktid/%FCn.s.19890518.1922.19890518.html (in Estonian); Adalbert Knöbl, Andres Sutt, Basil Zavoico, *The Estonian Currency Board: Its Introduction and Role in the Early Success of Estonia's Transition to a Market Economy*, IMF Working Papers, WP/02/96.

14 *Industrial Policy in an Enlarged Europe*, Commission of the Europan Communities, Brussels, COM(2002) 714 final.

15 *2002 Regular report on Estonia's progress towards accession*, Commission of European Communities, COM(2002) 700 final, http://europa.eu.int/comm/enlargement/report2002/ee_en.pdf. The same position was repeated in the report published by the European Commission on 5.11.2003: *Comprehensive monitoring report on Estonia's preparations for membership.*

16 Johannes Stephan, *Industrial specialization and productivity catch-up in CEECs, patterns and prospects*, IWH, June 2002, 16, http://www.iwh-halle.de/projects/productivity-gap/.

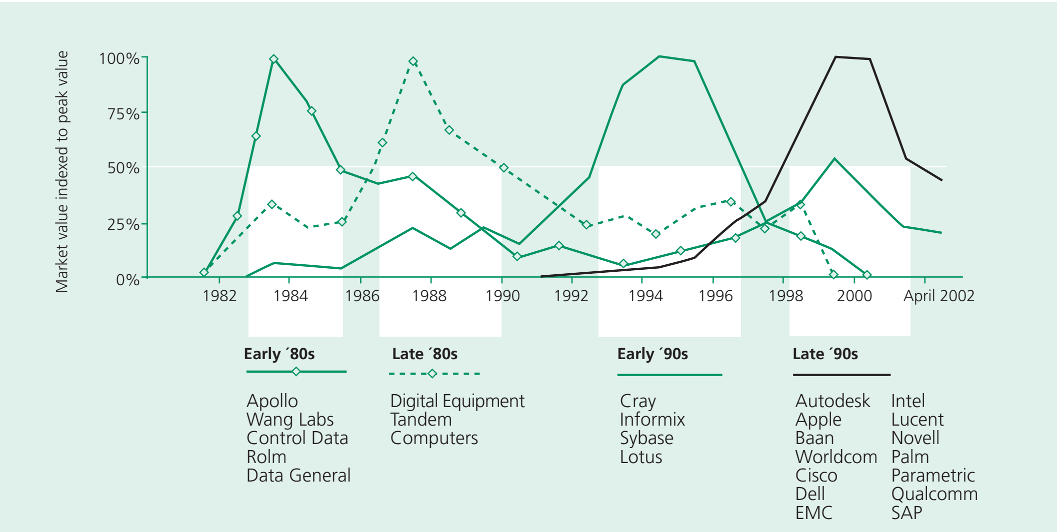
1.2. Socio-economic development and techno-economic paradigms

Economic development is not smooth and linear, but proceeds dynamically with sudden leaps. In the second half of the 19th century, analysis of business cycles was one of the favourite pursuits of many economists. The concept of business cycle is based on the knowledge, obtained through relatively uncomplicated observations, that economic growth is not linear. Instead, economic growth slows down after each 5–6 year period and then continues in a fresh frenzy. Karl Marx explained this with overproduction, but the first one who attempted to give a comprehensive explanation of a business cycle was Ukrainian-born economist Mikhail Tugan-Baranovski.[17] He explained the business cycle in terms of interplay between financial sector and production sector, where financial capital always seeks economic activities with ever higher quality since distribution of knowledge makes competitive advantages derived from research diminish quickly. [18]

Despite the infinite faith into „the new economy" that overtook the world in the end of the 1990s, the value of the historic wisdom described above has by no means faded.[19] Analysis of the developments in the last decades of the 20th century continues to illustrate that virtually all high technology companies, even the biggest market leaders, who focus on one specific product have to face extremely short lifecycles.

Most high technology companies experience 3 or 4 years of miraculous growth and profits, which is often followed by a no less remarkable collapse. In the second half of the 1980s, for instance, it was *Digital Equipment Corporation*, *Wang*, *Control Data* and *Tandem* that were the true world leaders in information technology; *Cray*, *Sybase* and *Informix* all managed to both rise and fall within the first half of the 1990s. By the end of the decade *Lucent*, *Palm*, *Parametric*, *Novell* and others had taken over as market leaders. (Figure 1)

Figure 1. **Technological development and economic cycles.**



Source: Mercer Management Consulting, December 2003, http://www.mercermc.com/Books/HowToGrow/traditional_techtrouble.asp.

It is important to note that the fate of specific companies does not necessarily quite coincide with economic business cycles or fluctuations in stock exchange prices. Instead, changes in the market value of a company are related to the saturation of its product market, competitors' attacks and shifts in the priorities of its

17 Tugan-Baranovski, *Osnovō polititseskoi ekonomii,* 3rd ed., St. Petersburg, 1915; see also Vincent Barnett, „Tugan-Baranovski as a Pioneer of Trade Cycle Analysis", *Journal of the History of Economic Thought*, 23, 4, 2001.

18 John Maynar Keynes' demand driven economic policy is actually an extension of this very reasoning. According to his theory, government should be investing precisely during the downfall phase of business cyle in order to keep the economy from descending into crisis.

19 A similar stock market bubble and the following crash in the USA of late 1920s was later even the subject of many mordant jokes – everyone buying stocks supposedly received a revolver for free, and hotel owners enquired while booking rooms: „to sleep or jump?" (sic!), see Robert Heilbroner, *The worldly philosophers. The lives, times, and ideas of the great economic thinkers*, Touchstone Books, 7th ed., 1999, 250.

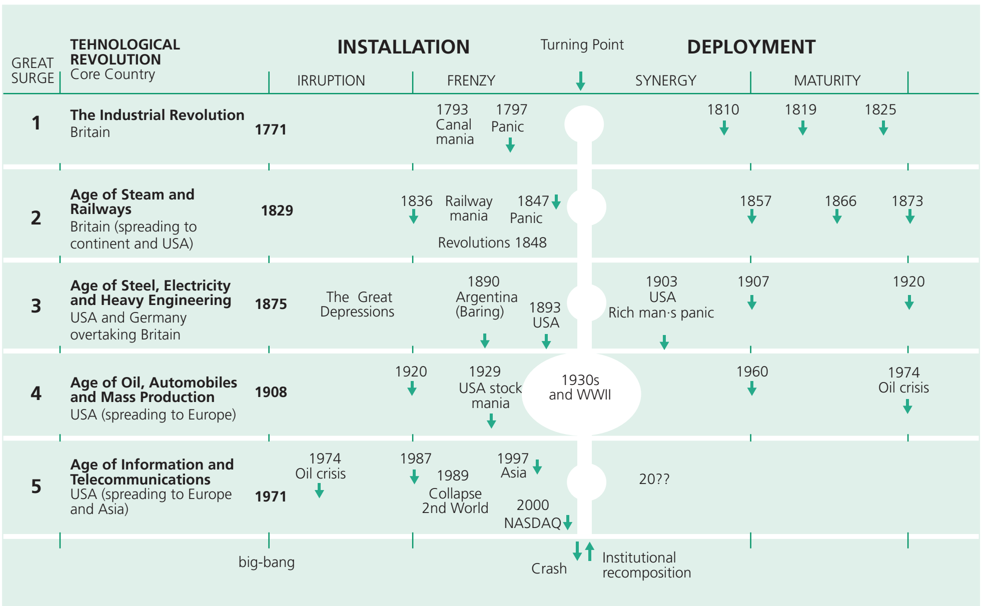
clients. It is thus important to learn from the above that a business relying on (high) technology product development is extremely unstable by nature and requires a strong strategy.[20]

Technological advantages once gained will disappear within a relatively short time period. Every new generation of a product is based on small incremental improvements. At the same time, this whole business is essentially jeopardised by new technologies. Tape cassette replacing record (LP) in the music industry, for instance, illustrates these developments. CDs and DVDs took over later, and now they, in turn, are threatened by completely different internet based dissemination and sales systems.

This shift between product generations driven by new knowledge and values, and, in turn, demanding change in the broader institutional environment, is what causes the cyclic nature of socio-economic development.[21] Contemporary economics shows that business cycles, again, converge into longer waves that have their own internal structural logic and last for about half a century. These waves are called techno-economic paradigms.[22] Paradigms emerge as a result of certain radical scientific inventions and enormously massive investments made towards their commercialisation and wide-scale utilisation of their corresponding productivity increasing technologies.[23]

Foundations to the explosively rapid development of the past couple of hundred years of the capitalist economy[24] were laid by the British industrial revolution (1790-1840s), which was followed by the age of steam and railways (1840-1890s), the age of electricity and steel (1890-1940s) and the so-called Fordism or the age of mass production (1940-1990s). The techno-economic paradigm of information technology that was going through rapid development in the 1990s has thus reached the turning point that comes right after the burst of a financial bubble. (Figure 2)

Figure 2. **Evolution of techno-economic paradigms and economic crises.**



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

20 Michael E. Porter, *Competitive strategy*, Free Press, 1998.

21 2004 Nobel prize laureates in economics Eward Prescott and Finn Kydland have demonstrated that 70% of the cyclic nature of American economy in the period after the Second World War resulted from technological developments.

22 The first one to prove this was Nikolai Kondratjev, a student of Tugan-Baranovski; see „Die langen Wellen der Konjunktur“, *Archiv für Sozialwissenschaft und Sozialpolitik*, 56, 3, 1926, 573-609 and „The long waves in economic life“, *Readings in Business Cycle Theory*, Philadelphia – Toronto, Blakiston, 1944, 20-42 . See also Christopher Freeman and Francisco Louçã , *As time goes by – From the Industrial Revolutions to the Information Revolution*. Oxford, Oxford University Press, 2001; Carlota Perez, *Technological Revolutions and Financial Capital. The Dynamics of Bubbles and Golden Ages*, Cheltenham - Northampton, MA, Edward Elgar Publishers, 2002.

23 For a brief overview see the video recording of a presentation given by Carlota Perez at a seminar held on 27th September 2002 in Tallinn, at the Ministry of Economic Affairs and Communications http://www.praxis.ee/innovation/workshop/.

24 Angus Madisson, *The World Economy: Millennial Perspective*, OECD, Paris 2001.

The most important lesson we can learn at this point from the above historic experience is that information and communication technologies based productivity growth and economic development are by no means exhausted yet. Events that took place a few years ago in this technology sector resemble the crash of the canal building mania in England and elsewhere during the first half of the industrial revolution; by 1847-1848 railroad construction boom had led England and the US into a comparable situation.

These episodes most certainly did not denote the end of either the industrial revolution or the age of steam engines. Likewise, the collapse of NASDAQ stock index in no way implies that information society is now complete or that the potential for socio-economic development embedded in the information and communication technologies is somehow exhausted. Information technology sector that now yields highest productivity growth thus infiltrates into other sectors with information technology performing as an enabling tool, and triggers introduction of organisational (replacing hierarchical structures with networks, for instance) and financial innovations (various derivative instruments).

History of economics reveals that paradigms last for nearly half a century. First they evolve at an explosive rate in a narrow field of technology until the technology offers so many different possibilities of use and has become so cheap as to enable virtually all branches of industry to rapidly increase their productivity.

The first – installation – period of a paradigm is ruled by financial capital,[25] which is boosted by the more liberal economic environment (incl. capital markets!). History has demonstrated that after the speculative boom that always emerges in the middle of a paradigm as a result of excessive investment, and the following collapse, cash flows often shift towards second and third world countries that have different economic structure. Thus economic rise and fall eventually also reach them. Production capital takes over the lead position in the following development. As a result, attention in economic policy shifts more towards regulating supply and/or demand side of the economy. While focusing on these policies governments very often forget about reinforcing strict monetary policy and macroeconomic balance, which, in turn, may lead to collapses resulting from overproduction. These alternations in the lead role in economic development occupied first by financial and then by production capital, including the impact of paradigms on social and political trends, to a large extent also explain historic shifts from liberal trade policy to more protectionist periods and back — during the 20th century as well as earlier.[26]

The internal logic behind the evolution of paradigms operates in a very similar fashion to the way new industrial branches emerge within paradigms (Figure 3):

- In phase one, it is inevitable that due to limited dissemination of knowledge only very few companies are able to make use of the considerably improved technologies, which have been created in the process of scientific research and may have taken several years or decades to materialise[27], and to generate applications for the new emerging markets. This creates extremely asymmetric markets where products are completely unique, all solutions are protected by patents and clients are forced to pay the price that is basically as high as whatever the seller fancies to ask for the product. This is an easy way to give rise to monopoly markets where "the winner takes all" and where there is consequently much to win but just as much to lose.

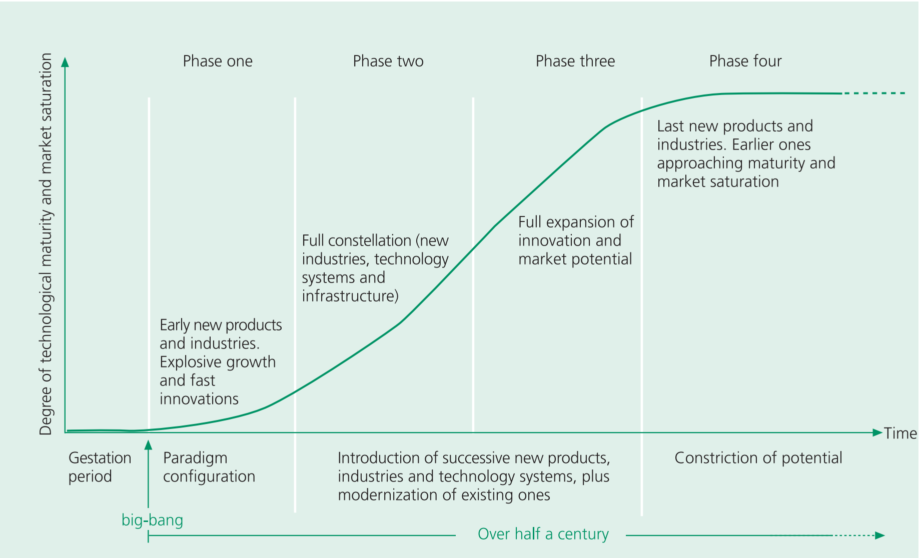
[25] Carlota Perez's techno-economic paradigm approach also offers a possibility to interpret the emergence and collapse of the Soviet Union in relation to the triumph and exhaustion of mass production paradigm that dominated the better part of the 20th century. During the *perestroika* period the Central Committee of the CPSU understood very well that „success in external economic activities is only possible through extensive exploitation of scientific and technical advances, relevant training for the cadre, overtaking of new markets and other similar activities" (see *NLKP Keskkomitee pleenumi materjalid, 27-28. jaanuaril 1987* („Proceedings of the plenum of CPSU Central Committee, 27-28 January 1987"), Tallinn, Eesti Raamat 1987, 62). But the Soviet model was based exclusively on the command-controlled economy and was lacking the complementary free financial capital, which would have allowed for investments separate from the existing economic structure to stimulate new paradigm based economic activities. As a fatal coincidence the new information and communication technologies driven paradigm also happened to contradict directly the profound ideological convictions of the Soviet block that had locked itself behind an „iron curtain". (Seminars by Carlota Perez held on 24-25th April 2003 in Tallinn).

[26] For further insights into the role of financial capital and innovation see especially Leonardo Burlamaqui, "Schumpeterian Competition, Financial Innovation and Financial Fragility: An Exercise in Blending Evolutionary Economics with Minsky's Macrofinance", 2000, http://les1.man.ac.uk/cric/schumpeter/papers/6.pdf; and Hyman Minsky, "Uncertainty and the Institutional Structure of Capitalist Economies", Jerome Levy Institute, Working paper No. 155, 1996, 33.

[27] These are typically massive long-term investments into basic research made by public sector, international corporations or small knowledge-based companies.

- In the following phase, the quality of these innovative products becomes fit for mass consumption; emerging competition and decrease in prices lead to explosive growth of market, and massive amounts of new infrastructure is being constructed. This is also the time when the largest profits are extracted from this market. That type of explosive growth occurred in the mobile communications sector in the second half of the 1990s, which largely accounts for the phenomenal economic growth Finland experienced at that time. Finland "cashed in" full profits from the investments made into telecommunications related research and development, first mostly by the government and later increasingly by private companies.

Figure 3. **Life cycle of a technological revolution.**



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

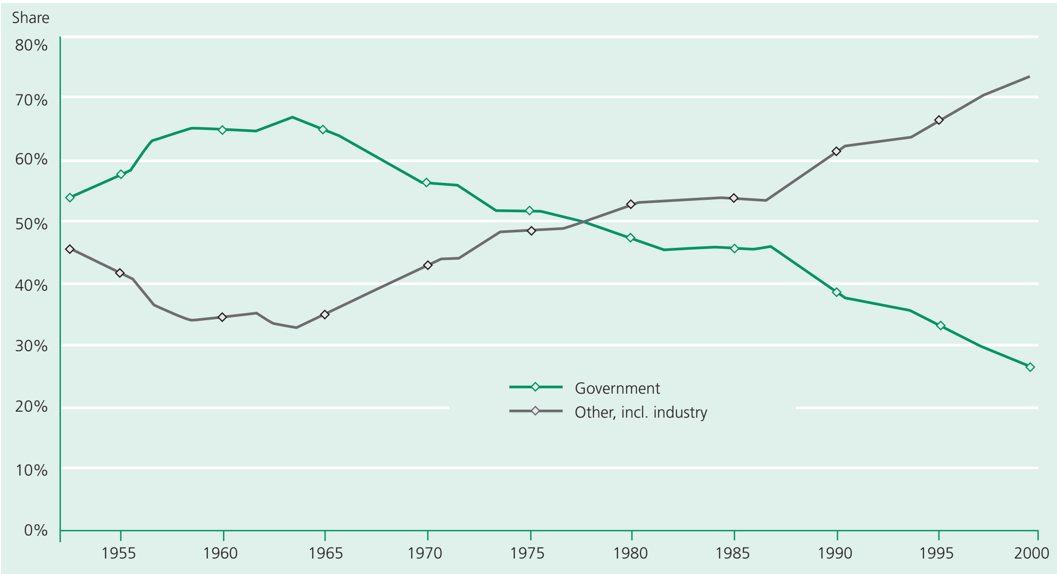
- Further development of the technology leads to the convergence of solutions offered by different manufacturers. Since all participants on the market can now offer identical solutions in regard to main functions, then the user does not really care anymore whether a particular mobile phone is created in the research and development laboratories of one or another company. In this period, at the latest, standards are established on the market that allow for combination or replacement of solutions developed by various producers. As the markets occupied first are becoming saturated, production as well as further development of existing products is simultaneously transferred to developing countries and/or other continents, i.e. closer to new markets and cheaper labour force.[28]
- Eventually the potential of the innovative technology that once initiated the development becomes completely exhausted. Respective industries, that are now already of low technological level, get transferred to less developed countries. Innovative technologies and products once again start dominating the economic activities.

Economic competitiveness of a small country is thus evidently based on: a) the increasing share of medium and high technology companies in the generation of added value and particularly in export, and b) the actual nature and quality of the knowledge and technology base of these companies. In other words, are we in the right paradigm or are we just trying to use low-cost labour to succeed in the framework of an old paradigm, and thus implementing and developing technologies that generate no more of a major growth in productivity?

[28] The above approach to socio-economic development also helps to explain why over the past decades the share of service sector has significantly grown in the economies of advanced countries. Under the circumstances of globalisation and free movement of capital, goods and services, it is reasonable to organise production in such a manner that the largest possible share of strategic research and product development and knowledge-based services are kept as close as possible to company headquarters while the better part of routine assembly line and other similar functions get transferred into regions where the cost of labour is lower and that are, at the same time, located as close as possible to the destination markets.

It will probably come as no surprise to anyone, by now, that for the past 200 years USA has essentially been the most successful country in developing its economy right in line with the paradigm framework. Alexander Hamilton's *Report on Manufacturers*[29] and the increasing investments by the current US administration into future technologies share the common feature of focusing on constant renewal of economic structure and environment along the lines of technological development.[30] This situation is well illustrated on Figure 4, which shows that in the gestation and early stages of a new paradigm government investments into research and development constitute a much larger share than those of the non-governmental sectors. This share decreases remarkably by the point when technology has reached the level where private sector can already earn significant profits and continue to invest on its own.

Figure 4. **Research and development funding in USA 1953-2000 (shares).**



Source: National Patterns of R&D Resources: 2000, National Science Foundation.

At the same time, rapid dissemination of knowledge and technology (especially in the developed world) means that the productivity gained from a certain technology cannot continue to grow endlessly. Its slowdown occurs in inverse proportion to the dissemination of technology, since competition is growing fiercer and the potential of the relevant technology is becoming exhausted. In this situation a renewed growth in productivity is derived from a new technology and its corresponding paradigm. This new technology once again gives rise to asymmetric markets and division of knowledge. Therefore research, development and innovation policies must always adhere to the specific technology and its development stage.[31]

1.3. Innovation and cluster-based economic policy

As demonstrated above, the quality of economic activities or their knowledge and skills intensity changes over time. Maintaining and increasing a country's standard of living is thereby only possible via the renewal of existing competitive advantages and continuous movement towards new emerging or rapidly developing knowledge-based markets.

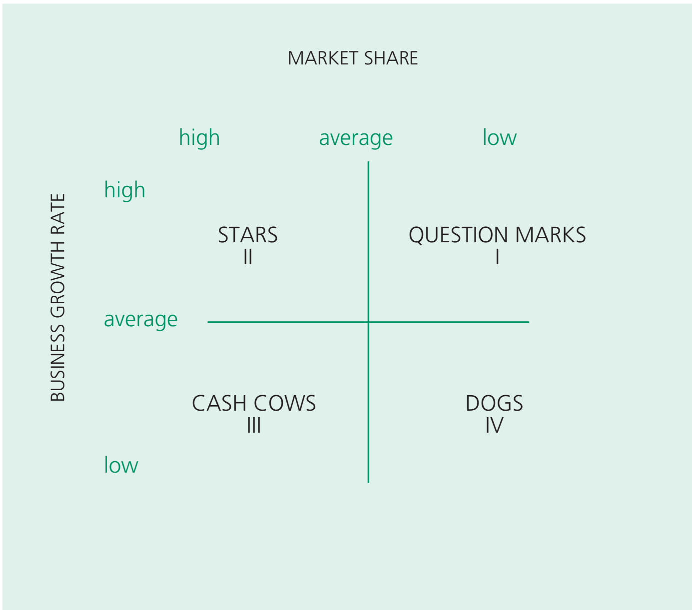
[29] Alexander Hamilton, *Report on Manufactures, Essential Documents in American History, Essential Documents*, 1492-Present, 1.

[30] We should also rememeber that in USA it is not only the federal government but also the state lavel that invest into future technologies and advancement of business.

[31] Marek Tiits, Rainer Kattel, Tarmo Kalvet, *The Estonian Economy. Competitiveness and Future Outlooks*, Research and Development Council, Tallinn 2003.

The core strategy for the entire social and economic development is continuous investment in scientific research required for the conception and development of new, hopefully emerging industries (so-called "question marks"). The objective is to become a "star" by gaining a favourable competitive position (patents etc) and as large as possible market capacity by the time the new market reaches its growth phase. As time passes, growth of this new market will slow down. Knowledge intensity is no more the primary means of gaining market control, and market share of the company, size of this market share, power of trademark, chances of arranging production at as low costs as possible etc become significantly more important. These markets become "cash cows" where a favourable market position still allows for reaping fairly good profits, but such opportunities are generally about to get exhausted. (Figure 5)

Figure 5. **Matrix of growth and market share.**



Source: *Perspectives on Experience,* Boston Consulting Group, Boston, MA, 1974.

Depending on the specific field of science and technology, advanced countries mostly invest in research and development with a view to possible breakthrough in 3–10 years time, but investments with significantly longer time horizon are not unusual either. Such long-term contributions towards future entail considerable risks at all times. Since there is no way to predict future it can always happen that the breakthrough expected in a particular field will never be achieved.

Markets with slowing pace of growth, where a company has only attained a relatively weak position (so-called „dogs"), are better left behind early on since the chances for achieving either growth or profits on such markets are gradually declining. Government, at the same time, has to create opportunities for employing the released labour as well as capital in some new field.

The choice of which new markets the entrepreneurs will attempt to enter in a free market situation is not predictable with much certainty, but it is not completely arbitrary either. In a capitalist economy entrepreneurs are operating in free market conditions that are determined by direct market forces as much as they are by chance and decisive government policy (or lack of it).

Development of a country as a whole and increased welfare of its people thus requires striking a certain balance between market and government. Lack of decisive government policy is therefore just as bad as command economy type of „excessive regulation", since both entail lost opportunities for development and pointless complications for private entrepreneurs.

Adam Smith, the founder of modern economic theory and policy introduces the concept „invisible hand" in *The Wealth of Nations*[32], his main work on economic theory. Even today it is still the most widely used phrase for describing the mechanisms of free market. Adam Smith believed that self-regulation by the market is one of the components of the broader social system.[33] He describes how it is only **after** the necessary preconditions for economic development are established[34] that the resulting economic progress leads to the emergence of the „invisible hand" effect – economy seems to be developing and growing automatically, giving rise to increasing specialisation and facilitating the development of domestic economy, where this much regulation and other kind of state intervention is therefore not necessary anymore.[35]

Business opportunities and profitability of investments for a specific entrepreneur are thereby directly dependent upon the earlier developments in that region. Progress in science and technology, in economic and social spheres, and in natural environment, all full of unexpected twists and turns, casts an endless line of new business opportunities into the hands of entrepreneurs. Ability of each individual entrepreneur to make the best of these opportunities will, however, largely depend on factors external to direct market competition. Existing human factor, availability of natural resources, market power of big corporations in monopoly position, and other aspects can either hinder or facilitate the exploitation of these opportunities.[36]

Essentially the same idea is advocated by some of the more recent thinkers like John Williamson, author of the economic reforms' package that became widely known as the „Washington Consensus", and Francis Fukuyama, author of the famous book „The End of History". Welfare of a country depends on its broader institutional and socio-economic environment that defines free market.[37]

Then again, the knowledge of how to construe the emergence of new economic sectors and how to use decisive economic policy to establish a favourable economic environment to facilitate their evolution is, however, quite well known across the globe as well as easily accessible. In his *Principles of Economics* that he published in 1890 Alfred Marshall devoted a whole chapter to "industrial quarters", which he defined as a geographically concentrated set of industries that have specialised in a specific field.[38] A century later, a neo-Marshallist approach surfaced again in the form of modern, cluster-based economic theory in the works of Harvard University Professor Michael Porter. It should not come as much of a surprise that Ireland was the first country to implement Porter's theory in the 1990s.[39]

Porter's theory is now widely used for economic policy planning in North-American, Scandinavian and other advanced countries. His theory states that the evolution and competitiveness of economic clusters, i.e. certain groups of industry that are located in close geographic proximity, depend on four interacting factors of the so-called "Porter's diamond": a) firm strategy, structure and rivalry; b) quality of available human resources and infrastructure; c) factors influencing market demand; d) availability and development of related and supporting sectors. [40] (Figure 6)

32 Adam Smith, *The Wealth of Nations*, London, Campbell, [1776] 1991.

33 See also Robert Heilbroner, *The Worldly Philosophers, The lives, times, and ideas of the great economic thinkers*, Touchstone Books, 7th ed, 1999.

34 Smith interpreted the establishment of necessary preconditions for development in terms of the country's broader socio-economic context that guides the evolution of free market. This context also included the mercantilistic protective mechanisms (especially customs) that England applied to defend its internal market and industry.

35 Adam Smith, *The Wealth of Nations*, Volume 4, Chapter II, 399; see also Erik S. Reinert, "The Role of the State in Economic Growth". *Journal of Economic Studies*, 1999, vol. 26, issue 4/5, 268-326. Friedrich List and his works from the 19th century have played an important role in the development of an industrial policy section in economic policy. He was the first one to articulate the need for infant industry protection, and said that it is only when the necessary skills and production volumes are established that the economy should shift towards the open market logic. In essence, List has also articulated how the whole catching-up logic made a significant contribution to Germany's development in the second half of the 19th century. See, for instance, *Das natürliche System der politischen Ökonomie*, [1837]1927, 280-289.

36 W. B. Arthur, 'Self-reinforcing Mechanisms in Economics', in P.W. Anderson, K. Arrow, D. Pines (eds.), *The Economy as Evolving Complex System*, Redwood City, California: Addison Wesley 1988, 9-31.

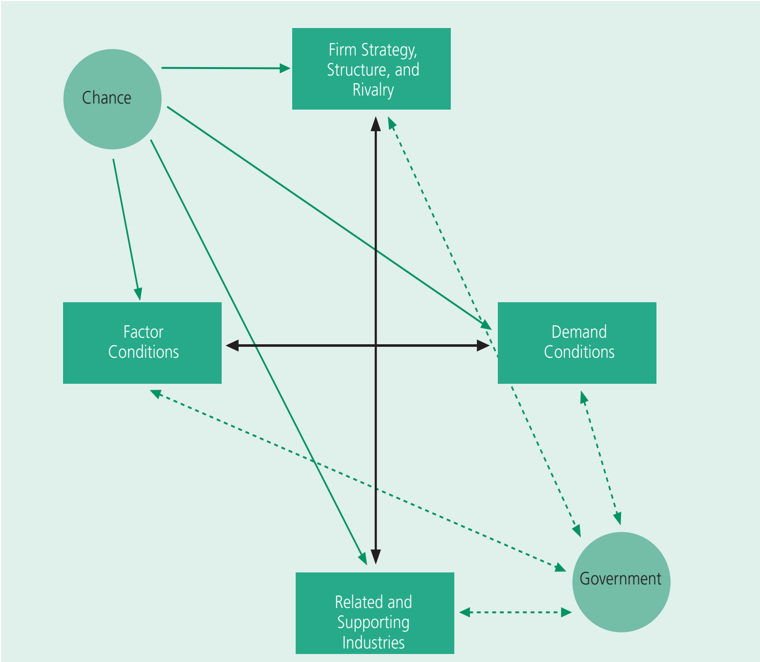
37 Francis Fukuyama, *State Building: Governnance and World Order in the Twenty-first Century*, Profile Books 2004; For a more detailed account of the role of government and external factors in economic development see, for example: Paul M. Romer, ‚Increasing Returns and Long-Run Growth', *Journal of Political Economy*, 1986, 94, 5 (October 1986), 1002-1037; Ha-Joon Chang, *Globalisation, Economic Development and the Role of the State*, Zed Books 2003.

38 Pierro Formica, *Industry and Knowledge clusters: Principles, Practices, Policy*, Tartu, Tartu University Press, 2003.

39 Lars Mjøset, *The Irish Economy in a Comparative Institutional Perspective*, Irish National Economic and Social Council, No. 93, 1992.

40 Michael E. Porter, *The Competitive Advantage of Nations*, London, Macmillan, 1990.

Figure 6. **„Porter's diamond" depicting main factors influencing the evolution of economic clusters.**



Source: Michael E. Porter, *The Competitive Advantage of Nations*, London, Macmillan, 1990.

Most important among these factors is the availability and generation of top quality human resources in respective sectors. Necessary preconditions can be provided only through a modern educational and research system. **Government demand for specific education and research is one of the main instruments besides classic economic policy methods that can and must be used to steer change in the structure of economy towards generating higher knowledge-intensity, i.e. higher level of value added. This is where government plays the central role, since it is only the government that has the capacity to do this.**

The core message of this approach does not diverge from that of the other theories of economic development that have become classics by now. Their uniform view is that the primary engine of socio-economic development resides in innovation and growth in the knowledge-intensity of economy.[41]

Timely investment in the creation of the necessary knowledge base for the future needs of an economic cluster opens up certain windows of opportunity for entering economic sectors that grow faster, rely on suitable level of technology and promise greater profits.[42] Such a knowledge base thereby also creates prospects for the evolution of a high-technology export oriented industry in the respective sector. All other impacts resulting from economic environment play an equally important role in the development of companies that have already established themselves on the market as well as in the emergence and evolution of clusters.

One of the causes for the problems Estonian labour market is currently facing resides in the fact that the country has not prepared itself for the transformations in labour demand that inevitably accompany structural changes in economy. Then again, preparations for modernising economy must always be forward-looking in

[41] According to Joseph A. Schumpeter (one of the most important theoretics of all times in the field of innovation), technological change drives economic development. However, it is not the technology itself that develops economy, but the entrepreneurs who seek, find and exploit new solutions and opportunities (innovation). Joseph A. Schumpeter, „The economy as a whole. Seventh Chapter of the theory of economic development", *Industry and Innovation*, 2002, 1/2, 93-145; On the role of knowledge in economy see, for example *Managing National Innovation Systems*, OECD, Pariis 1999; R.A.Boschma, G.A.van der Knaap, „New high-tech industries and windows of locational opportunity: the role of labour markets and knowledge institutions during the industrial era', *Geografiska Annaler*, 81b, 2, 1999, 73-89.

[42] R.A.Boschma, G.A.van der Knaap, ‚New high-tech industries and windows of locational opportunity: the role of labour markets and knowledge institutions during the industrial era', *Geografiska Annaler*, 81b, 2, 1999, 73-89.

their nature, and there is not much sense in adjusting Estonian educational and research system to the currently existing low technology based economy (although this seems to be what the market is calling for).

There is virtually no local clustering in either Estonian industry or research landscape. On the other hand, successful Estonian companies are getting increasingly integrated into Nordic clusters. The above-mentioned logic of economic development tells us that one of the primary tasks of public policy is to facilitate clustering. Actual situation in Estonia, however, implies that the chances for domestic clustering are essentially utopic in either short or medium term (5-15 years). What options does a country have in a situation like this?

1.4. Varying policy needs of countries in different stages of development

The top five technologically most advanced countries in the world, whose population comprises only 10% of the total population on the Earth, produced approximately 41% of the global gross national product in 1995. At the same time, 69% of world population live in countries that are not capable of any technological innovation, and the total gross national product of these countries accounts for 38% of the gross national product of the whole world. In one of his treatises Jeffrey Sachs has classified the world according to three groups – developers of new technologies, their appliers and the outsiders incapable of one or the other.[43] What would the latter benefit from having research and innovation policy, and should they be thinking about it in the first place?

Adam Smith has articulated what is today known as a classic insight: if economy is to develop and grow, different institutional mechanisms are to be implemented in different stages of economic development. Smith also outlines the gravest mistake a country can make in the development of its economy[44] – implementing policies that do not correspond to the country's level of development, for instance, excessively liberal economic policy in a country with low export capacity.[45]

Countries with the world's highest standard of living are the leaders of economic development, and they have achieved this position because their domestic research and technological development are at the absolute top level of the world. All these countries have one or several industries that control a large share of the respective global market where they dictate the highest possible price.[46] The more freedom there is in the world for the movement of capital, goods and services, the more extensive economies of scale these industries and economies enjoy. Continuous new advances at the cutting edge of research and technology are indispensable for maintaining the living standard and economic – and frequently also (geo)political and military – position of these countries. Headquarters of the majority of international corporations are also located in these countries.

In the modern world, it is the big corporations, who surpass many countries in regard to their economic power, that partially, yet not by far completely, take over the long-term future oriented investment (research and development etc) functions associated with the „invisible hand", while in a small catching-up country such functions can be performed only by the government. A catching-up country simply does not have any other mechanism to execute these functions, since its market comprises small companies planning their business in the maximum of 0.5-1 year timeframe thus lacking both sufficient knowledge and capital for such tasks.[47]

In Sachs' classification the group of catching-up countries capable of absorbing modern technology comprises countries that have managed to create or maintain from earlier times a sufficiently favourable economic environment. They have enough social and human capital to be capable of applying relatively early on the new technologies created elsewhere. This group includes also Estonia whose economic success over the past

43 Jeffrey Sachs, „A New Map of the World", *The Economist*, 22.06.2000.

44 This argument works in Estonian context as well – foreign trade deficit has not disappeared within the past ten years.

45 Adam Smith, *The Wealth of Nations*, Volume 4, Chapter II, 399; see also Erik S. Reinert, "The Role of the State in Economic Growth. *Journal of Economic Studies"*, 1999, vol. 26, issue 4/5, 268-326.

46 Michael E. Porter, *The Competitive Advantage of Nations*, London, Macmillan, 1990.

47 This does not imply that people filling certain positions are somehow automatically smarter than others nor that the government could perform these functions alone independent from the market. – Neoclassic economic theory says that this is a classic market failure situation. Several other modern economic theories, on the other hand, are of the view (partially on the grounds of Serra's idealistic tradition of active government) that the very definition of government entails certain obligation to nurture the most favorable conditions possible for sustainable socio-economic development.

decade derives mostly from its capacity to attract foreign investments that have brought the capital needed for development, and have helped make the economy more effective. There is no realistic way for these countries to leap overnight into developing cutting-edge high technology based industries.

The main challenge facing Porter's investment-based economies of catching-up countries (incl. Estonia) lies in their capability to be innovative while learning to use and develop the latest imported technologies, simultaneously with establishing domestic industry that is competitive on international markets.[48] Degree studies and research are critical to countries in this phase of development for enhancing the quality of human resources and establishing the basis for future new high technology industries and economic sectors.[49] At the same time, these processes also require far-reaching support from economic policy.

If competitive advantages are not being continuously renewed there will not be enough of high quality productive resources, and the stimulus to domestic productive investments as well as to the influx of foreign investments will diminish or disappear. At some point potentially available domestic and international resources for investment will be exhausted, and further additions are not possible. A particularly dramatic representation of these developments is manifested, for instance, in a whole range of African countries, but also in Mongolia and elsewhere.

Nevertheless, it should also be kept in mind that the structure of an economy cannot be changed overnight. Path dependency is intrinsic and important to both successful catch-up and unsuccessful economic development. In the case of Estonia the desire to rapidly forget about where we come from is completely reasonable; yet understanding the meaning of the extensive alteration of the economic environment that took place in 1991-1992 is critical to today's and even more to future strategies of economic development. Majority of companies found themselves and emerged in the environment that surpassed them by several decades; there was clearly no way to simultaneously survive under these extremely liberal circumstances and make significant investments into knowledge etc. Same applies to consumption habits, labour market, financial services[50] etc. Not only has Estonia's economy and society dramatically changed over the ten years, but certain institutional frameworks have emerged and become established. The latter will be critical preconditions for development also in the coming 5-10 years. Estonian entrepreneurs will not engage overnight in knowledge and skills-intensive production (be it potato harvester or breast cancer medication).

Even a failed attempt at high technology development can make into a project that is extremely beneficial for a country like Estonia – but only if government stops acting as a bystander and engages vigorously in generating and supporting entrepreneurship also in sectors related to the specific high technology. For example, in the case of biotechnology, these related sectors can range from pharmaceutical and chemicals industries up to food and wood processing industries. In other words, the government would have to implement cluster-based economic policy. In such a case, even a failed high technology project generates new links between entrepreneurs, scientists and officials; developments and reforms take place, for instance, in the system of vocational education and in labour market policies etc. A new contender or **an entrepreneur** can take advantage of all this. The government has already borne part of the risks on his and his competitor's behalf. This is not to suggest that the government has to allocate some sort of subsistence allowances. Instead, the government should provide Estonian entrepreneurs as favourable conditions for business as developed countries do.

In summary, the logic of industry development goes as follows: high technology sectors are developed by decisive public policies – from research funding to patent subsidies and venture capital – that are, however, grounded in the needs and opportunities of that specific country and society, which are, in turn, determined by the existing industry structure and skills level. Industrial and innovation policies must always be twofold covering both high technology and existing industries. This is the only way that clusters and thereby virtuous circles can emerge, successively leading to increased standard of living.

48 In his classic book *The Competitive Advantage of Nations* that was published in 1990 Michael Porter calls this phase of economic development investment-based, and speaks of innovation-based economic model in reference to developed countries. Yet modern (OECD and others) approach to the concept of innovation is much broader, encompassing also technology transfer, organisational transformation, financial innovation etc that consitute the basis for economic development in the invesment-based economy.

49 Moses Abramovitz, *Thinking About Growth*, Cambridge, Cambridge University Press, 1989; Michael E. Porter, *The Competitive Advantage of Nations*, London, Macmillan, 1990.

50 On this point see Andres Juhkam, "Financial innovations in Estonia", PRAXIS Working Paper 6/2003.

1.5. Specifics of the catching-up strategy in small states

Recognition of certain resource restrictions that exist in socio-economic development and need to be taken into consideration while elaborating public policies is not at all new. The first one to cite the scarcity of (natural) resources as a limiting factor to economic growth was Malthus. In 1817, during the final phase of British industrial revolution, David Ricardo published *The Principles of Political Economy and Taxation* that explicated these mechanisms in greater detail, and concurrently put forward an original theory of economic development, which highlighted capital accumulation in modern industry as the engine of economic development.[51]

Since successful socio-economic development is grounded in investment into new high technology industries and in simultaneous modernisation of traditional sectors, small states nowadays, unfortunately, find themselves in a particularly complicated situation with their strategic choices strained by the two simultaneous developments. On the one hand, limited resources and growing complexity of developing basic technologies for high technology sectors impede small states from establishing a sufficiently strong infrastructure for research and development. Small (domestic) market does not permit entrepreneurs to make sizeable and ever increasing investments into research and development, especially under the conditions of shortening product life cycles and tightening competition.

On the other hand, global market for low and medium technology products is increasingly dominated by the scale and cost advantaged and rapidly industrialising South East Asian „tigers", China, and India with Russia most likely to join them in the longer run.[52] Consequently smaller scale of production together with relatively higher transaction costs make it generally rather difficult for small countries to compete on production costs also in traditional sectors. This forces otherwise equally advanced industries into seeking export opportunities and/or establishing foreign production bases earlier than it would happen in larger countries. This pressure on domestic companies to internationalise quickly should not be automatically viewed as a weakness of a national innovation system, but rather as a special feature that relates to small size.

Overcoming all these pressures requires that small countries make as optimal use of technology and market globalisation as they can by implementing appropriate policies to modernise local competencies and technological base. On the whole, to enhance their human resources and competitiveness through research and development European small countries have to choose between the following strategies:[53]

I. Investing in the development and commercialisation of basic technologies

This strategy is common in large countries, but Sweden and Switzerland have also tried it, though unsuccessfully. Implementing it in a small country requires extreme mobilisation of resources, meaning essentially extensive reorganisation of the whole economy according to the strategic objectives set by technology and industrial policies.

II. Observing the policies of big corporations and subsidising their strategic choices

This strategy has been adopted by the Netherlands, though not always successfully implemented. This is *de facto* a national champion strategy, which presupposes that one or more big corporations have located their headquarters in that country. Focusing on the interests of big corporation(s) might turn out to have adverse impact on small and medium sized enterprises that are not able to keep pace with the speed of technological development. Production rationalisation decisions by big corporations can also lead to sudden changes in labour market.

[51] Yujiro Hayami, *Development Economics. From Poverty to the Wealth of Nations*, Oxford, Clarendon Press 2000, 66-67.

[52] Cees van Beers, *The role of foreign direct investment on small countries' competitive and technological position*, Government Institute of Economic Research, Helsinki 2003, http://extranet.vatt.fi/knogg/Reports/t100.pdf; About China's massive industrialisation since 1950s see also: Angus Maddison, *The World Economy: Millennial Perspective*, OECD, Paris, 2001, 43.

[53] Cees van Beers, *The role of foreign direct investment on small countries' competitive and technological position*, Government Institute of Economic Research, Helsinki 2003, 8-9.

III. Focusing on rapid application of new knowledge and skills, and supporting investment in specific technology niches

This strategy proves successful only when the small country has a clear understanding of its strengths and weaknesses, and is able to respond to changes in the market competition in a timely manner. Broadly speaking, the longer the country waits, the less options it will have, and the more expensive the catching up with more developed countries becomes.

It was already explained above (see Ch 1.2) that basic research requires very long term investments forcing a small country into extreme resource mobilisation. In addition, there is no 1:1 linear causality between investments into basic research and successful spin-off into economy or emergence of high technology industry. It must be remembered that the choice of developing basic technologies involves long term and extremely large investments in actual numbers into the supposedly emerging „winner takes all" type of markets. Therefore, this strategy is not really an option for a country with a medium or low standard of living.

Although Estonia does not headquarter any multinational corporations, experiences of Ireland, Malaysia, Singapore and others have demonstrated that in certain circumstances the same role can be performed by „the right kind" of foreign direct investments. Implementing this strategy, however, requires exceptionally professional and determined public policy development; including enforcement of convergence between the policy of attracting high technology focused foreign direct investments and the existing structure of economy, and a proactive technology transfer policy to ensure that the know-how accompanying the foreign direct investments actually gets passed on to domestic enterprises.

Analysis of the evolution of Finnish telecommunications industry over the past half-century, on the other hand, reveals an excellent example of how focusing on a specific technological niche resulted in a successful breakthrough into the world market and establishment of a multinational corporation deeply rooted in Finnish domestic base. Even though nobody could foresee such developments several decades ago, Nokia's success in 1990s actually goes all the way back to the efforts of developing Finnish military radio communications systems in the 1960s.[54]

Likewise, many of Estonian scientific achievements that have triggered vigorous commercialisation efforts in recent years have, in fact, resulted from investments made into higher education and research no less than 10-20 years ago. The volume of Estonia's annual investment in research and development is equivalent to some big corporation's weekly research and development expenditures; and Estonia's scientific workforce of approximately 3,000 researchers (in full-time equivalents) is comparable to some medium-sized lab in Europe or the US. Even if Estonia did manage to rapidly increase its investments to the level of 3-4 per cent of GDP, we would still remain but a very modest contestant on the international scale. Yet Estonia's existing research and innovation policy has undertaken to follow the assumption that Estonia is just as big a player as the US or the European Union are.[55]

While large countries are undeniably the ones to determine the direction of scientific and technology development, the limited resources available to Estonia inevitably force the country into setting priorities and thereby taking on very substantial risks. This makes systematic forward thinking unavoidable for a small country (or a smaller region of a large country). In this regard it is of particular importance to develop human resources not in line with the existing structure of the economy and the limited domestic market, but according to the desired direction of foreign investments and evolution of global economy.[56]

[54] Martin Fransman, *Knowledge and sectoral innovation systems: the mobile communications industry evolved largely by getting things wrong*, http://www.ie.ufrj.br/globelics/pdfs/GLOBELICS_0028_MartinFransman.PDF.

[55] The above does not, however, mean that investment into basic research is either insignificant or unnecessary for a small country. Yet, it would be rather short-sighted of us to hope that every kroon or euro invested into research can be cashed out as profit earned in the same economy without carrying out any changes in its structure. Ensuring the quality of higher education, including degree studies etc is what should rather be expected as the primary output of such investments.

[56] See Alan Rugman, Joseph R D'Cruz, "The Double Diamond Model: Canada's Experience", *Management International Review*, 33, 1993; Leo van Grunsven, Chris van Egeraat, "Archievements of the Industrial 'High-road' and clustering Strategies in Singapore and Their Relevance to European Peripheral Economies", *European Planning Studies*, 7, 2, 1999.

2. Key areas of research and technology

2.1. Future visions for information, bio- and nanotechnology – 2015-2020

The US National Science Foundation, RAND Corporation, the US National Intelligence Council,[57] European Commission, various large corporations and many others involved in developing future scenarios all envisage a major information, bio- and nanotechnology and cognitive sciences based techno-economic revolution in the coming 10-20 years time. This revolution will radically change virtually all fields of our everyday life, and will simultaneously offer opportunities for faster economic development than any other area of research and technology would. In a way, information, bio- and nanotechnologies can be viewed as horizontal technologies that promise significant productivity growth in all fields of life and all branches of economy.[58]

In the same vein, Estonian research and development strategy *Knowledge-based Estonia 2002-2006*[59] outlines the same areas of information technology and development of information society, biomedicine, and materials technologies as key areas of research, technology development and innovation that open up a whole range of new opportunities for economic development. This must not, however, mean that the country will narrow-mindedly focus on (high) technology or macroeconomic growth estimates alone, and forget all about the surrounding reality together with Estonia's current strengths and weaknesses. Quite the opposite – the objective of *Knowledge-based Estonia* strategy is that all fields of everyday life develop through the prioritised development of the aforementioned technologies and their extensive application. Alas, so far, no clear understanding has emerged in Estonia about what will be those areas where we expect rapid socio-economic development to take place, nurtured by global advances in research and technology, of which we might take advantage by smartly committing our limited resources.

The founder and Chairman Emeritus of Intel Corporation Gordon Moore noted already in 1965 that the number of transistors that fit on Intel microprocessor doubles in about every 18 months, and this pattern, nowadays called Moore's Law, predicts exponential growth in the number of transistors a microcircuit can hold.[60] This trend for the number of transistors to double every couple of years, which, in turn, allows for decreasing the size of electronic components and growing computation capacity, has continued for decades – while *Intel 8008* microprocessor, created in 1972, only held 2500 transistors, the contemporary *Itanium2* microprocessor already holds more than 400 million transistors. *NEC Corporation* recently announced that it has developed currently the world's smallest transistor with a gate length of about 5 nanometres, the size of which is only one-eighteenth of the previous transistors. This means that a microcircuit of one cubic centimetre can hold about 40 billion such new transistors. It is anticipated that these microcircuits should reach the market in around 2020. *Intel* itself also believes that this trend should generally persist for another 10-15 years when the existing methods for decreasing the size of transistors will hit their physical limits.[61]

Continuous rapid growth in computation and storage capacity, speed of data transmission etc will keep opening up opportunities for the emergence of new applications that were once thought inconceivable. This trend for persistent growth in computation capacity means that the performance of a computer equivalent to today's average personal computer will reach the level of information processing capacity of one human being already by the year 2010, and by the year 2020 it will be equal to the aggregate of the whole population of planet Earth.[62] Although the social acceptability of these technologies is ethically questionable due to the blurring of boundaries between human and computer, technological developments are already unlocking the path to the use of various miniature implants injected straight into brain to enhance human capacities, for instance, by improving a person's information storage capacity, computation and language skills etc.[63]

57 See *National Science Foundation*, http://www.nsf.gov/; *Rand Corporation*, http://www.rand.org/; *U.S. National Intelligence Council*, http://www.cia.gov/nic/.

58 See e.g. Philip S. Anton, Richard Silberglitt and James Schneider, *The Global Technology Revolution: Bio/nano/materials. Trends and Synergies with Information Technology by 2015,* RAND Corporation, http://www.rand.org/publications/MR/MR1307/MR1307.pdf, 2001.

59 *Teadmistepõhine Eesti. Eesti teadus- ja arendustegevuse strateegia 2002-2006*, RTI 2001, 97, 606.

60 Gordon E. Moore, "Cramming More Components Onto Integrated Circuits", *Electronics*, 19.04.1965, http://download.intel.com/research/silicon/moorespaper.pdf.

61 See e.g. *NEC Develops World's Smallest Transistor*, IDG News Service, 08.12.2003, http://www.infoworld.com/article/03/12/08/HNnectransistor_1.html; Victor V. Zhirnov, Ralph K. Cavin, James A. Hutchby and George I. Bourianoff, *Limits to Binary Logic Switch Scaling – A Gedanken Model*, Proceedings of IEEE, 91, 11.11.2003, http://www.intel.com/research/documents/Bourianoff-Proc-IEEE-Limits.pdf; "Intel prepares for next 20 years of chip making", *Computerworld*, 25.10.2004, http://www.computerworld.com/printthis/2004/0,4814,96917,00.html; Stephen Baker, "Nano and Chips: Uneasy Ties", *BusinessWeek*, 07.02.2005, http://www.businessweek.com/technology/content/feb2005/tc2005027_4712_tc119.htm.

62 See Ray Kurzweil, *The Age of Spiritual Machines: When Computers Exceed Human Intelligence*, New York: Penguin Books 2000.

63 Michael C. Roco and William Sims Bainbridge (eds), *Converging Technologies for Improving Human Performance*, World Technology Evaluation Centre, http://www.wtec.org/ConvergingTechnologies/Report/NBIC_report.pdf, 2002.

Various research and development projects currently under way as well as the amendments being introduced into legislation in different locations across the world are solid proof of these developments not being a mere science fiction. Development of ID-card type of personal identification devices that can be implanted in human body has already been in progress for years, and now the US Food and Drug Administration (FDA) has officially confirmed their safety for use in various identification, security and financial applications. FDA has also granted permission for human clinical trials of brain implants that make it possible to use brainpower to give commends to computers. In Europe there are also several *cyborg* projects that have been in full swing for several years now.[64]

Moreover, a technology chief from The Defence Advanced Research Projects Agency (DARPA) in the US believes that the Agency can build a thinking robot by 2030. Various field elements of the robot's artificial intelligence, such as reasoning and speech recognition, will most likely be completed much sooner.[65]

Sensors that can be integrated into clothing, electronic ink, disposable paperboard computers produced in Sweden,[66] cubic millimetre sized wireless networks of minute computers (Smart Dust)[67] used in environmental monitoring and other areas as well as other devices are early examples of this kind of drastic shrinking in the size of computer technology, and of the continuing extraordinarily rapid evolution of information technology. Ray Kurzweil describes possible developments as follows: *„Computers are now largely invisible. People routinely use three-dimensional displays built into their glasses, or contact lenses. These "direct eye" displays create highly realistic, virtual visual environments overlaying the "real" environment. This display technology projects images directly onto the human retina, exceeds the resolution of human vision, and is widely used regardless of visual impairment. … Computers routinely include wireless technology to plug into the ever-present worldwide network, providing reliable, instantly available, very-high-bandwidth communication.* "[68]

The prerequisite to continued evolution of information technology is, however, embedded in the sustained development of microelectronics and materials technologies (Figure 8). Just like the invention of transistors 55 years ago created the technological preconditions for the emergence of contemporary electronics industry and of the whole information technology paradigm, reports about the creation of certain early molecular transistors and memory devices[69] are a similar sign of possible dramatic changes in the structure of information technology systems that will hit their physical limits in some very distant future.[70] Yet the link between information, bio- and nanotechnologies works also in the opposite direction. Evolution of information technology is, in turn, a precondition for the development of novel bio- and nanotechnologies that perform sufficiently well and are suitable for application on a massive scale

For example, the equipment nowadays needed for DNA synthesis costs approximately 10,000 USD, but its price is decreasing rather rapidly due to technological advances, and thereby makes such „tools" more broadly accessible. This implies that the expected persistence in the growth of the capacity of computation technology described my Moore's Law will bring about fairly dramatic changes in the coming decade or so, both in biotechnology research and in the potential social and economic perception of biotechnology.

While the Human Genome Project took 13 years to complete the sequencing of human genome in 2000, growth in technological capacity described above implies that by the year 2010 every individual would be potentially able to sequence or synthesise 10^{10} pairs a day. And in ten years time the sequencing of an individual's DNA will take merely a few seconds. Comparison of these developments in biotechnology with the nowadays popular open-source software, such a *Linux* and others, would easily suggest that the world is moving towards „open-source" biological systems, i.e. they are available for modification by anyone.[71] (Figure 7)

[64] See *U.S. Food and Drug Administration*, http://www.fda.gov; Kevin Warwick, 'Identity and Privacy Issues raised by Biomedical Implants'. *IPTS Report 67: 29-34*, European Commission Joint Research Centre 2002, http://www.jrc.es/pages/iptsreport/vol67/english/IPT5E676.html.

[65] See Frank Tiboni, „DARPA tech chief envisions the future", *Federal Computer Week*, 19.04.2004, http://www.fcw.com/fcw/articles/2004/0419/feat-brachman-04-19-04.asp.

[66] See David Gardner, „It had to happen: the disposable computer", TechWeb.com, 04.03.2004, http://www.techweb.com/wire/story/TWB20040304S0005 and http://www.cypak.com.

[67] Jim Butler, „Mobile Robots as Gateways into Wireless Sensor Networks", Deviceforge.com, 02.05.2003, http://deviceforge.com/articles/AT2705574735.html.

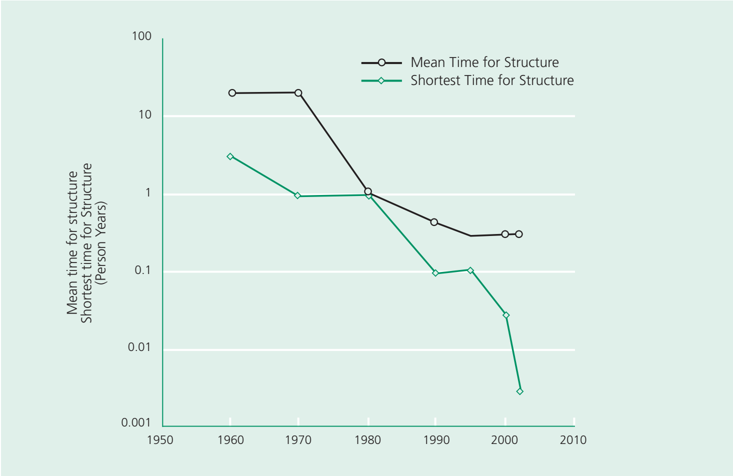
[68] Ray Kurzweil, *The Age of Spiritual Machines: When Computers Exceed Human Intelligence*, New York: Penguin Books 2000.

[69] E.g. a molecular memory device with the potential of holding 40 GB per square centimeter, for details see http://www.eurekalert.org/pub_releases/2004-04/uosc-spn042004.php.

[70] See e.g. Peter Weiss, "Shrinking toward the Ultimate Transistor", *Science News*, 10. 08.2002.

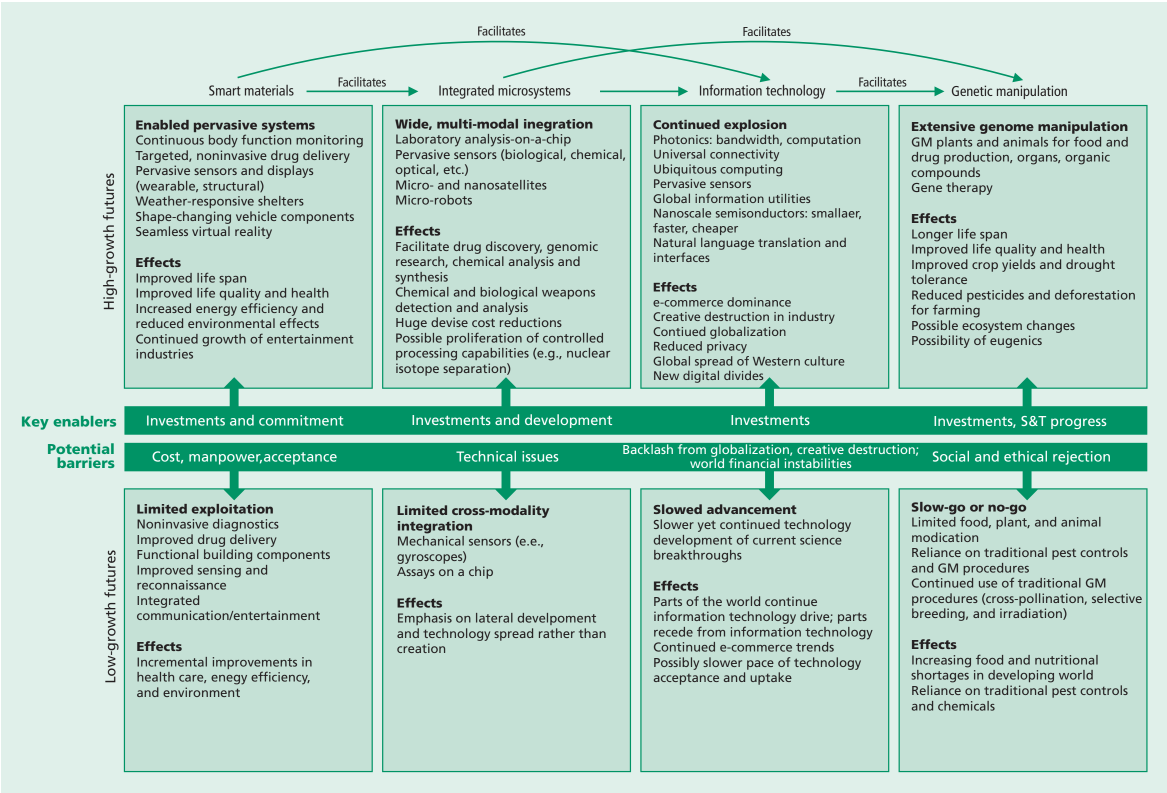
[71] See Robert Carlson, „Open-source Biology and Its Impact on Industry", IEEE Spectrum, 2004; Robert Carlson, „The Pace and Proliferation of Biological Technologies", *Biosecurity and Bioterrorism: biodefence strategy, practice and science*, 1, 3, 2003.

Figure 7. **Time for DNA sequencing and synthesis (person years).**



Source: Robert Carlson, „The Pace and Proliferation of Biological Technologies", *Biosecurity and Bioterrorism: biodefence strategy, practice and science*, 1, 3, 2003.

Figure 8. **Potential interacting areas of materials technologies, microelectronics, information and gene technology by 2015.**



Source: Philip S. Anton, Richard Silberglitt and James Schneider, *The Global Technology Revolution: Bio/nano/materials. Trends and Synergies with Information Technology by 2015,* RAND Corporation, http://www.rand.org/publications/MR/MR1307/MR1307.pdf, 2001, 37.

Broadly speaking, the objective in developing nano- and biotechnology is to have technology open up dramatically novel opportunities for people to shape the diversity of materials and living organisms. In the natural environment, diversity exists in places where it has emerged during the evolutionary process; the goal of bio- and nanotechnology is to create devices that enable people to generate and exploit the diversity of nature at a time and place they choose to.

50 years have passed since first successful organ transplant on a human being, and the scientific ambitions cultivated in the field of biotechnology have, by now, reached way beyond this level. There are various rather significant projects currently in progress all around the world that strive to produce “spare parts” for human beings by means of biotechnology. So for instance, scientists at the University of Manchester are actually developing an inkjet printer type of device that is able to “print out” tailor-made human cells to fit a patient’s exact dimensions.[72] Scientists in *Johns Hopkins Medicine* believe they are close to being able to create biological pacemakers on the basis of genetically engineered heart cells developed from human embryonic stem cells, and thereby replace today’s rather inconvenient electronic pacemaker.

Kurzweil describes one possible image of future: “*Direct neural pathways have been perfected for high-bandwidth connection to the human brain. … there is extensive use of communication using direct neural connections. This allows virtual, all-enveloping tactile communication to take place ….*”[73]

One of the very trends in today’s technological thinking is to imitate the operating principles of nature in information technology (networks of nerves, genetic algorithms etc) as well as in all other spheres of everyday life. So for instance, *Nexia Biotechnologies* in Quebec, Canada produces „spider silk” from goat milk, and by imitating the structure of spider web they could create, for example, bullet-proof clothing that covers the whole body.[74] A counterbalance to this would be another well-known natural phenomenon found in the wings of certain butterflies that makes clothing invisible even to night vision equipment, for instance.

The most tangible indication of the development of these three key areas of technology having a dramatic and unavoidable impact on the world in the coming decades is the decision by the governments of USA, Japan and many others to rapidly increase the volume of research and development funding for bio- and nanotechnology. (see Ch 2.4 and 4.5).[75]

Yet, on the whole, these changes are of the kind that no one remotely concerned about the future and personal privacy of him- or herself or their children should remain indifferent to. While changes in the natural environment result from evolution and struggle for existence determines the general direction, development of science and technology lacks such an external limiting factor like evolution. Therefore the human being must be its own regulator able to determine the proper path for technology and other means that it manipulates. Thus the future of technology is important in regard to economy just as much as it matters in social and ethical terms. Whereas information technology is already being extensively exploited, we still have no clue about the actual capacity of bio- and nanotechnology, about the true intentions of entrepreneurs, about possible consumer reactions etc. This all makes the tasks facing policy-makers, scientists and entrepreneurs unprecedentedly complex.[76]

It is the more important then, for the future of Estonia, to cautiously estimate at least some trends in what and how the global development of research and technology (for the most part unaffected by Estonia) will influence, and what individual developments might mean or hold out for Estonia. Staying informed about these global trends is one of the major functions of Estonian research even if we are not able to make a fast profit in one or another field of research. The only two choices Estonia has are either to follow the global trends or degenerate.

72 About a possible biological pacemaker and biotechnology-based spare parts for human beings see also http://www.hopkinsmedicine.org/Press_releases/2004/12_20_04.html; “Skin and bones ‘made to measure’”, *BBC News,* 18.01.2005, http://news.bbc.co.uk/2/hi/uk_news/england/manchester/4184627.stm.

73 Ray Kurzweil, *The Age of Spiritual Machines: When Computers Exceed Human Intelligence*, New York: Penguin Books, 2000.

74 See http://nexiabiotech.com/.

75 See also Brad Wieners, „Eight Technologies That Will Change the World”, *Business 2.0*, June 2002, http://www.business2.com/b2/web/articles/0,17863,514755,00.html.

76 On this point, it must be added that many of the information, bio- and nanotechnology related innovations and experiments have today also become particularly important in connection with the current war on terror.

2.2. Development of information technology and information society

Extensive spread of Internet and modern personal computers is, by far, not a sign of the end of information technology revolution – quite the opposite, in economic terms it is only getting started.[77] In the context of techno-economic paradigms (Figure 2 in Ch 1.2) the year 2005 means that the information technology related financial bubble has already burst (2001) and that we are currently entering the „golden age" of information technology that is characterised by synergy and continuing of profound social and economic changes due to expanding application of information technology; this stage is estimated to last 20-30 years.[78] Various analysts claim that information technology is one the primary means of achieving economic development since it is supposed to account for approximately 50% of recent economic growth.[79]

Up to the year 2020 key trends in the development of information and communication technologies will include not only the aforementioned convergence of materials technologies, microelectronics, information and biotechnology (see Ch 2.5), but also the realisation of the concept of Ambient Intelligence, which, in turn, leads to dramatic developments, for instance, in the public sector (e-government, e-democracy etc), services sector (e-services etc) as well as manufacturing sectors.

The concept of Ambient Intelligence (AmI),[80] which is based on the idea of ubiquitous computing, is at the very heart of all the various information technology sector related technology overviews and strategies developed by the European Commission for the year 2020 as well as other equivalent analyses. This concept was originally introduced by Marc Weiser, computer scientist in *Palo Alto Research Center* (Xerox PARC) already in 1988:

> *Since we started this work at Xerox Palo Alto Research Parc (PARC) in 1988 a few places have begun work on this possible next-generation computing environment in which each person is continually interacting with hundreds of nearby wirelessly interconnected computers. The goal is to achieve the most effective kind of technology, that which is essentially invisible to the user. To bring computers to this point while retaining their power will require radically new kinds of computers of all sizes and shapes to be available to each person. I call this future world „Ubiquitous Computing".*[81]

European Union's approach to AmI is, however, a further expansion of the Ubiquitous Computing concept comprising not only Ubiquitous Computing (1) and Ubiquitous Communication (2), but also the emergence of Intelligent User Friendly Interfaces (3).

The first one implies a change in paradigm where development moves from central mainframe computing towards personal computers, palm pilots and computers integrated into various objects. As a result, embedded information technology systems will be surrounding us everywhere. This will be complemeted by object-to-object communication, including convergence and compatibility of infrastructure systems, broadband wireless connection, digital broadcasting, satellite connection etc. Interfaces (sensors, speech recognition, biometry etc) consitute the third pillar of AmI. Their most important characteristic is user-friendliness or, in other words, the environment created for the communication between humans and the virtual world must be such that it resembles in every way possible the reality of people's everyday life with no computer

77 Due to diverging stages of economic development Estonia and Finland have different interpretations for the concept of *policy for information society*: in Estonia, information society related discussions focus on a more widespread application of Internet and mainly imported information technologies (*Tiger Leap* program of supplying schools with computers, e-government etc); in Finland, on the other hand, information society strategy has mostly emphasised the development of relevant domestic industry, broader socio-economic development and related innovations (economically sound application of new solutions).

78 Carlota Perez, *Technological Revolutions and Financial Capital: The Dynamics of Bubbles and Golden Ages*, Cheltenham, UK: Edward Elgar, 2002.

79 See e.g. OECD, *The OECD Information Technology Outlook 2004*, 2005, Paris: OECD; *Facing the Challenge, The Lisbon Strategy for Growth and Employment*, Report from the High Level Group chaired by Wim Kok, 03. 11.2004, http://europa.eu.int/comm/lisbon_strategy/pdf/2004-1866-EN-complet.pdf; PriceWaterhouseCoopers, *Rethinking the European ICT Agenda. Ten ICT-breakthroughs for Reaching Lisbon Goals*, 2004.

80 See e.g. *Ambient Intelligence: from Vision to Reality*, ISTAG, September 2003, ftp://ftp.cordis.lu/pub/ist/docs/istag-ist2003_draft_consolidated_report.pdf; *Strategic Orientations and Priorities for IST in FP6*, IST Advisory Group, June 2002, ftp://ftp.cordis.lu/pub/ist/docs/istag_kk4402456encfull.pdf; *Software Technologies, Embedded Systems and Distributed Systems,* June 2002, IST Advisory Group ftp://ftp.cordis.lu/pub/ist/docs/istag_kk4402472encfull.pdf.

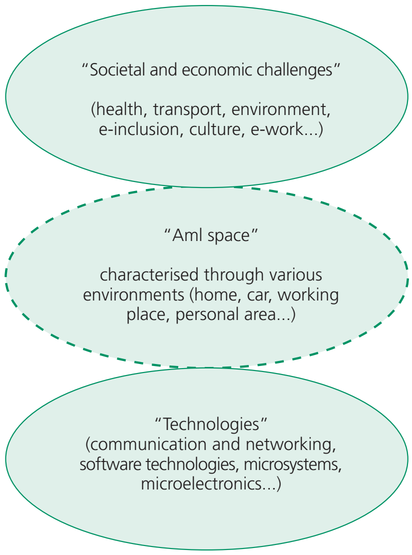
81 Marc Weiser, "Some Computer Science Issues in Ubiquitous Computing", *Communications of the ACM*, 1993, 36, 7, 75-84, 75.

mice, keyboards or display screens. Therefore it is a far-reaching vision about the future development of the Information Society where the emphasis is on greater user-friendliness, more efficient services support, user-empowerment, and support of human interactions.[82]

Information Society Technologies Advisory Group (ISTAG) anticipates the realisation of this vision already by 2010: by that time people should be surrounded by intelligent intuitive interfaces that are embedded in all kinds of objects; AmI is capable of recognising and responding to the presence of different individuals, it operates in a seamless, unobtrusive and often invisible way.

In the context provided by Marc Weiser, ISTAG's AmI vision presents nothing radically new. Then again, in addition to techno-economic efficiency Europe has always paid more attention to the broader social context than America does.[83] Along these lines ISTAG has adopted a three-layered model where the societal and economic challenges are located in the upper layer, technologies in the lower layer, and the two are linked together by Ambient Intelligence. (Figure 9)

Figure 9. **„Ambient Intelligence", technologies and socio-economic challenges.**



Source: IST Advisory Group, *Strategic Orientations and Priorities for IST in FP6*, 2002, ftp://ftp.cordis.lu/pub/ist/docs/istag_kk4402456encfull.pdf, 17.

Realisation of this vision entails AmI meeting the following technology requirements: very unobtrusive hardware; a seamless mobile/fixed communications infrastructure; dynamic and massively distributed device networks; natural feeling human interfaces (including the use and design of new software applications and materials); and dependability and security. Societal and economic challenges, in turn, influence the development of technologies and are currently very important for Europe, including issues like aging population, health care, cultural diversity, learning patterns, administrative matters and security etc.[84]

82 For an illustrative example see *Scenarios for Ambient Intelligence in 2010*, Sevilla: IPTS, IST Society Technologies Advisory Group (ISTAG), 2001; see also *Väljavõte Infoühiskonna Tehnoloogiate Nõukogu (ISTAG) raportist "Näiteid ümbritsevast intellektist – visioone aastaks 2010"* [An excerpt from the Information Society Technologies Advisory Group (ISTAG) report „Scenarios for Ambiernt Intelligence in 2010"], 2002, http://www.esis.ee/eVikings/foresight/Visioonid_final.pdf, translation into Estonian by SA Archimedes 2001.

83 Compare also, for instance, the principles of scientific management developed by Frederick Winslow Taylor in the USA of the early decades of the 20th century, and the discourses on the philosophy of administration by such British philosophers as Oliver Sheldoni, Josiah Charles Stamp and others; Rosamund Thomas, *The British Philosophy of Administration*, Cambridge: CBPSE, 1989.

84 For a detailed account of European Information Society scenarios see e.g. Rafael Popper, Ian Miles, Lawrence Green, Kieron Flanagan, *Information Society Technologies Futures Forum: Overview of Selected European IST Scenario Reports*, http://fistera.jrc.es/docs/Scenario_Pool_version_11.6.pdf, 2004.

A few of the applications developed in Estonia have already caught attention on the global scale (e.g. online banking, e-government), and vigorous advances in similar applications (e.g. applications operating through mobile communications infrastructure, e-health care) create further opportunities for realising Ambient Intelligence.

Yet, just like in any other situation there are threats that cannot be discarded. All these applications now being developed are linked to local services sector where the research intensity of innovations and thereby also the opportunity to protect these applications with patents, for instance, is much more limited in comparison to manufacturing sectors, and they are therefore more exposed to imitators (Ch 1.5). In addition, at this time the small size of domestic market significantly curbs the growth of companies as well as opportunities for launching knowledge intensive services.[85]

Realisation of the AmI vision in the coming decade will require a great deal of further scientific research and technology development in various fields. (Figure 10)

Figure 10. **Grand challenges and research trends.**

Grand Challenges \ **Research Challenges**	Cognitive Techno-logies	Human Interfaces	Software-Intensive System Development	Distributed Ambient Computing	Advanced Knowledge Manage-ment	Systems Modeling and Simulation	Next Generation Communi-cation Techno-logies	Nano-electronics, Architectures, and Sensing
The 100% Safe Car	●		●	●			●	●
The Multilingual Companion	●	●			●		●	
The Service Robot Companion	●	●		●	●			●
The Self-Monitoring and Self-Repairing Computer			●			●		●
The Internet Police Agent			●	●	●	●		
The Disease and Treatment Simulator		●	●		●	●		
The Augemented Personal Memory	●	●			●		●	●
The Pervasive Communication Jacket		●		●			●	●
The Personal Everywhere Visualizer		●				●	●	●
The Ultra-light Aerial Transport Agent	●	●	●	●		●		●
The Intelligent Retail Store	●	●	●	●			●	●
	6	8	6	6	5	5	6	8

Source: IST Advisory Group, *Grand Challenges in the Evolution of the Information Society*, 2004, fttp://ftp.cordis.lu/pub/ist/docs/fet/7fp-pre-6.pdf, 11.

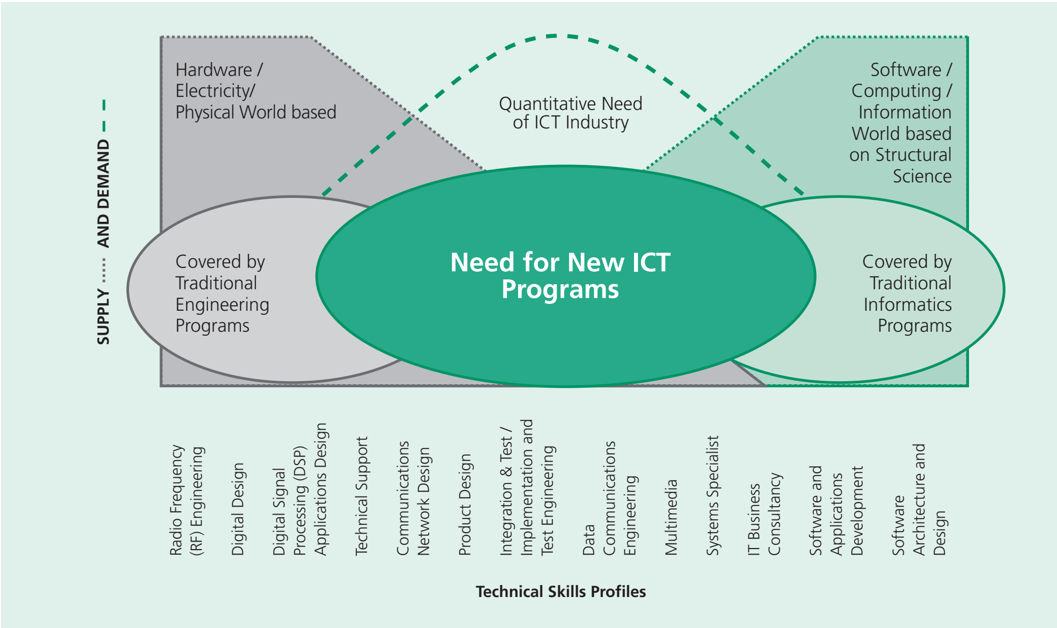
Approximately 100 information technology component or system trajectories up to the year 2020 have been forecasted within the framework of FISTERA (*Thematic Network on Foresight on Information Society Technologies in the European Research Area*) project. The forecasts are outlined in four layers: technology, its functionality, related services and the „ambient".[86]

[85] Rainer Kattel and Tarmo Kalvet, *Teadmistepõhine majandus ning infotehnoloogiaalane haridus: hetkeolukord ning väljakutsed haridussüsteemile aastani 2008* [Knowledge-Based Economy and Information Technology Education: Existing Conditions and Challenges Facing the Educational System up to the Year 2008], PRAXIS Center for Policy Studies, 2005.

[86] *Key European Technology Trajectories*, Telecom Italia Lab, 2003, http://fistera.jrc.es/docs/D2&appendix.pdf; the inteactive tool is available on: http://fistera.telecomitalialab.com/#.

An additional, but a no less important trend is the ever more interdisciplinary character of research and education. Thus, a cross-European evaluation of ICT curricula in relation to generic skills profiles was undertaken within the framework of Career Space project[87]. One of the more important problems outlined in this study was the fact that most information technology curricula have grown out of traditional study and research fields – physics and engineering sciences on the one hand, and mathematics and informatics on the other – while today's industry needs a synthesis of both fields and more. Since contemporary information technology companies not only produce, install and maintain information technology applications and systems, but have to be well versed in business processes and capable of envisaging relevant applications in this context as well, then solid foundations in both engineering and informatics must be complemented by a broader systems perspective for embracing all other fields – therefore both traditional engineering and informatics oriented curricula are needed along with more interdisciplinary and combined curricula.[88] (Figure 11)

Figure 11. **The profile of ICT industry needs depicting new curricula in comparison to the existing ones.**



Source: *Curriculum Development Guidelines, New ICT Curricula for the 21st Century Designing Tomorrow's Education*, Career Space and International Co-operation Europe Ltd, 2001, http://www.career-space.com/cdguide/serv2.htm.

2.3. Biotechnology

Discussions about the possible impact of biotechnology commonly use the classification of biotechnology into the so-called green, red and white biotechnology. The first one denotes agricultural (e.g. plants that are more resistant to various weather conditions), the second one medical (e.g. more effective medications), and the third one industrial (e.g. enzymes for producing plastic) biotechnology.

87 *Career Space* is a European Union partnership consortium with the world's leading infromation and communication technology companies – *BT, Cisco Systems, IBM Europe, Intel, Microsoft Europe, Nokia, Nortel Networks, Philips Semiconductors, Siemens AG, Telefonica S.A., Thales* and *the European Infromation, Communications and Consumer Electronics Technology Industry Association* (EICTA). See http://www.career-space.com/.

88 For a more detailed account see Rainer Kattel and Tarmo Kalvet, *Teadmistepõhine majandus ning infotehnoloogiaalane haridus: hetkeolukord ning väljakutsed haridussüsteemile aastani 2008* [Knowledge-Based Economy and Information Technology Education: Existing Conditions and Challenges Facing the Educational System up to the Year 2008], PRAXIS Center for Policy Studies, 2005.

2.3.1. Red biotechnology

The Last Human – this is precisely the title that Gregory Stock gave to the first chapter of his sensational book *Redesigning Humans* that was published in 2002.[89] Stock deems it inevitable that the opportunities offered by biotechnology to genetically change and „improve" a human (so-called germline engineering or changes that will also affect future generations) will be exploited sooner or later, and it is only the question of when and by whom. Today's generations stand on the threshold of posthuman future.[90] The opportunities biotechnology offers are now barely conceivable (for instance, to cure cancer or reproduce organs) but so grand in their essence, and the need for them, let alone potential economic benefits, is so obvious that it is hard to see all the threats that come together with these developments. Daniel Callahan, one of the first bioethicists suggests that there is only one way to fight them: to rewind the evolution of technology.[91]

Given that the application of biotechnology concerns a much more intricate process than merely changing the genetic map of living organisms,[92] then the more complex is also the whole red biotechnology related public policy, and should understandably play a major role in this regard – through decisions about development priorities, standards and the rest.[93]

Biomedicine related biotechnology is certainly the most well-known one in Estonia, since this is precisely where Estonia's main biotechnological competence lies in regard to both science and entrepreneurship. The general public has been introduced to this field via the Estonian Genome Foundation project. On the international scale red biotechnology has often been brought to the centre of attention by the persistently controversial debate over cloning, stem cells and the like. Red biotechnology is also widely represented in the economic activities of developed countries: for instance, red biotechnology occupies a significant share of biotechnology related economic activities in the US,[94] where biotechnology accounts for up to 46% of innovativeness in pharmaceuticals.[95]

Whereas the red biotechnology that emerged in the 1970s mostly exploited the existing knowledge about the effects proteins can have, then today this potential has already been exhausted – now we first have to find the protein that is linked to one or another disease. An important role is played here by genomics, proteomics, transcriptomics, interactomics, pharmacogenomics and the like that are all based on cataloguing and systematising proteins etc.[96]

Hence we can say that the biotechnology paradigm follows the changes in the treatment of diseases by moving towards personalised and preventive medicine, which is based on genetic studies and treatment with innovative medicines. This type of radical change is most supported by pharmacogenomics that uses the information about a person's genome to find and construct a cure. Stem cells research and xenotransplantation offer opportunities for the reproduction of tissues and organs to treat the irreversible illnesses and injuries caused by strokes, Alzheimer's and Parkinson's disease, burns and spinal cord injuries.[97]

Following from the above Figure 12 outlines the major trajectories in red biotechnology that the leading companies in this field mostly invest in.

89 Gregory Stock, *Redesigning Humans. Our Inevitable Genetic Future*, Boston/New York: Houghton-Mifflin, 2002.

90 See Francies Fukuyama, *Our Posthuman Future. Consequences of the Biotechnology Revolution*, New York: Farrar, Straus and Giroux, 2002.

91 Daniel Callahan, *False Hopes. Overcoming the Obstacles to a Sustainable, Affordable Medicine*, New Brunswick, NJ and London: Rutgers University Press, 1999.

92 The phrase „genetic modifications" is surrounded by numerous myths (about all that is possible), yet the biological reality is inevitably much more complex, and the causal role of genes in the development of organisms acutally limited. See for instance Evelyn Fox Keller, *The Century of the Gene*, Cambridge, MA and London: Harvard University Press, 2000, 133-148; then Michael Morange, *The Misunderstood Gene*, Cambridge, MA and London: Harvard University Press, 200; and Matt Ridley, *Nature via Nurture. Genes, Experience and What Makes Us Human*, London: Fourth Estate, 2003.

93 More specifically about the ethical challenges in pharmacogenetics see Nuffield Council on Bioethics, *Pharmacogenetics. Ethical Issues*. London: Nuffield Council on Bioethics, 2003.

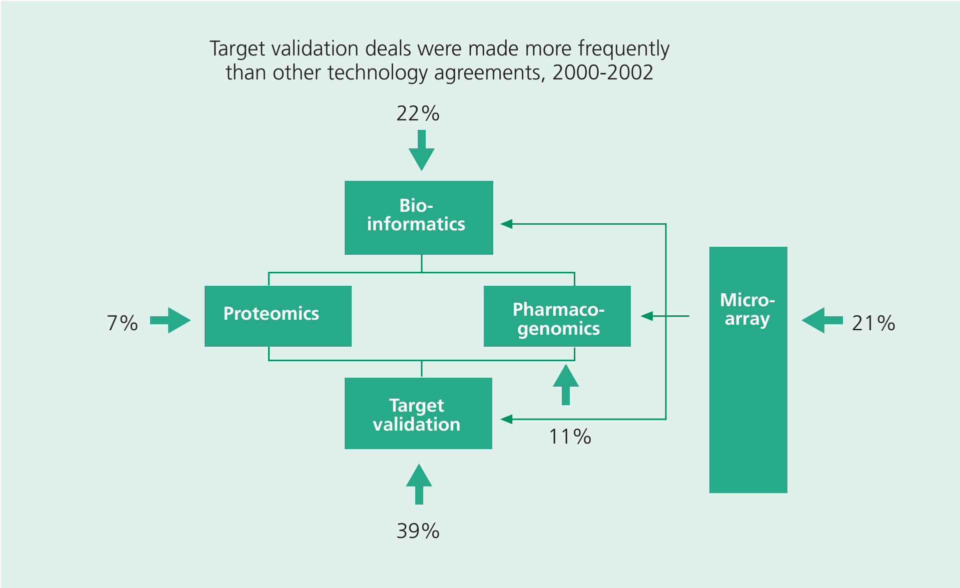
94 *A Survey of the Use of Biotechnology in US Industry*, U.S. Department of Commerce, Technology Administration, Bureau of Industry and Security, 2003, http://www.technology.gov/reports/Biotechnology/CD120a_0310.pdf.

95 European Commission, *Third European Report on Science and Technology Indicators*. Brussels: European Commission, 2003, 376.

96 For a good and concise overview see *The Economist*, "Survey: Biotechnology", 27.03.2003, http://www.economist.com/science/displayStory.cfm?story_id=1647556.

97 *Life sciences and biotechnology — A strategy for Europe*, Communication from the Commission to the European Parliament, the Council, the Economic and Social Committee and the Committee of the Regions, European Commission, 2002, 10-11.

Figure 12. **Licensing strategies of top 20 pharmaceuticals companies, 2000-2002.**



Source: *Licensing Strategies. Benchmarking Analysis of the Top 20 Pharmaceutical Companies*, Datamonitor, 2003.

2.3.2. Green biotechnology

Green biotechnology is commonly taken to mean genetically modified (GM) agricultural products and foodstuffs.[98] While medical biotechnology is well represented primarily in the developed countries and especially their economic activities, then green biotechnology has retained a rather inconspicuous position in Estonia. Yet, public debate about green biotechnology has been no less heated in the developing countries as it is in the developed ones.

Whereas biomedicine has so far only consumed sizeable investments without giving much in return, which has, in turn, made investors rather anxious in recent years, the situation in agricultural biotechnology is dramatically different.

In 2002, the market volume of GM agricultural products totalled at $4 billion, and GM agriculture took up 4% of the world's arable land.[99] While in 2001 GMO covered globally a total of 50 million ha of land, only 12,000 of it were in Europe.[100] USA clearly dominates GMO exports and actively urges developing countries to adopt extensive use of GM agricultural products with the promise of alleviating famine. Half the world's soybean crop is already genetically modified, and two-thirds of GM soybeans are grown in poor countries.[101]

98 See Daniel Charles, *Lords of Harvest. Biotech, Big Money and the Future of Food*, Cambridge, MA: Perseus, 2001.

99 For comparison see also the estimates by Princeton University, where the volume of GM agricultural product market in 2002 is suggested to amount to $17 billion, *Genes, Trade and Regulation: The Seeds of Conflict in Food Biotechnology,* Princeton University Press, 2003, http://www.pupress.princeton.edu/titles/7665.html.

100 *Life sciences and biotechnology — A strategy for Europe*, Communication from the Commission to the European Parliament, the Council, the Economic and Social Committee and the Committee of the Regions, European Commission, 2002, 11. About the plans to allow GMO commercialisation in the European Union and the United Kingdom see, respectively, „Seventeen GM varieties approved but coexistence decision postponed", *EurActive.com*, 09.09.2004, http://www.euractiv.com/Article?tcmuri=tcm:29-129877-16&type=News and „Britain gives go-ahead for first GM crop", *NewScientist.com news service*, 09.03.2004, http://www.newscientist.com/news/news.jsp?id=ns99994754.

101 "Survey: Biotechnology", *The Economist*, 27.03.2003, http://www.economist.com/science/displayStory.cfm?story_id=1647556.

There are two different sets of problems raised in debates about green biotechnology: technological (biotechnological) production of new living organisms or drastic modification of the existing ones, and industrial production of agricultural products. The first set is primarily concerned with the various technological solutions and their ethical acceptability or user-friendliness. The second set has to do with the problems of market competition and the dynamics of economic development: on the one hand, there is internationally varying regulation that creates barriers and excessive costs to GM products entering new markets,[102] and, on the other hand, there is the question of whether and how to protect innovation in agricultural production. This last matter is acutely controversial in the context of developing countries and poverty with the rights to agricultural production owned by the rich Western countries while the users are mostly developing countries.

Innovation paradox in agricultural production arises when a farmer buys, for instance, a new variety of grain, which might be specifically adjusted to Estonian weather conditions, but he still has the discretion to sow it, store it for the following year or do whatever he likes. Yet reselling this product or anything similar would mean direct damage to the breeder of this hypothetical grain variety. At the same time, epidemics and the like compel today's agricultural sector to continuously renew their products.[103] *Union pour la Protection des Obtentions Végétables* (www.upov.int), which Estonia joined in 2000, was called into existence in 1961 for the purpose of protecting new agricultural products through an arrangement similar to international patent system. Since 1994 all members of WTO are obliged to implement UPOV type of legislation. Given that the development activities of this field are performed basically only in the major European and US corporations,[104] dissatisfaction and varying interpretations are inevitable.

Moreover, development of technology has complicated the problem even further by exploiting natural diversity and adding hybridisation – whereby the plants of a new generation consequently have new characteristics. Since relevant technology itself limits exploitation due to its advanced level of complexity, there is no real need for various agreements and all that. Biotechnology effectively enables the genetic modification of such plants that do not become subjected to hybridisation in the natural environment, and thereby creates opportunities for the introduction of the so-called genetic use restriction technology (GURT). In simple terms, GURT denotes the manipulation of a plant's genetic traits in a way that makes them render sterile seeds, i.e. it is impossible to re-use the harvested seeds.[105]

Albeit GURTs are not in use as yet, their introduction is nevertheless highly probable seeing as it would essentially solve the paradox of the development activities in agricultural production. This will likely also lead to significant growth in the private sector agricultural development activities, which consequently implies an increase in prices and a decrease in public sector control. **Less developed and developing countries can obviously expect a major decline in the current level of agricultural research and development as they are not able to keep up with biotechnology.**[106]

In conclusion, the agricultural potential of biotechnology is expected to be employed primarily for the purpose of making production processes more environmentally friendly and generating higher quality foodstuffs. In the near future, genetically modified plants may have a considerable role in the achievement of the former. An example of this is a transgenic soybean *Roundup Ready* that was created in the 1990s and allows for farming without chemicals or constant ploughing.[107] This basically gives the opportunity to

102 For a detailed account see Thomas Bernauer, *Genes, Trade, and Regulation: The Seeds of Conflict in Food Biotechnology,* Princeton, New Jersey, USA: Princeton University Press 2003; *World agriculture: towards 2015/2030: Summary Report*, Food and Agriculture Organization of the United Nations, 2002, http://www.fao.org/docrep/004/y3557e/y3557e00.htm.

103 A concise overview of this whole range of issues is provided in Timothy M. Swanson (ed), *Biotechnology, Agriculture and the Developing World. The Distributional Implications of Technological Change*, Cheltenham, UK: Elgar, 2002.

104 See Charles Spillane, "Agricultural biotechnology and developing countries: proprietary knowledge and diffusion of benefits", in Timothy M. Swanson (ed), *Biotechnology, Agriculture and the Developing World. The Distributional Implications of Technological Change*, Cheltenham, UK: Elgar, 2002, 67-134, 74-78.

105 See Timothy Swanson, "Biotechnologies and developing world: how will the anticipated industrial changes in agriculture affect developing countries?" in Timothy M. Swanson (ed), *Biotechnology, Agriculture and the Developing World. The Distributional Implications of Technological Change*, Cheltenham, UK: Elgar, 2002, 3-21.

106 See Timothy Swanson and Timo Goeschl, "The impact of CURTs: agricultural R&D and appropriation mechanisms", in Timothy M. Swanson (ed), *Biotechnology, Agriculture and the Developing World. The Distributional Implications of Technological Change*, Cheltenham, UK: Elgar, 2002, 44-66, 61.

107 Jonathan Rauch, "Will Frankenfood Save the Planet?" *Atlantic Monthly*, October 2003, http://www.theatlantic.com/issues/2003/10/rauch.htm.

make arable land fertile (again), and thereby diminish deforestation and the like. In many less developed countries applying biotechnology to food production is even viewed as a matter of health care, since GM can offer more nutritious and healthy food to precisely the world's poorest countries. On the technology side, however, the main shortcoming of green biotechnology has stemmed from the fact that virtually all innovations have been producer, and not consumer oriented. It has been possible for several years now to produce vitamin-enhanced or healthier foodstuffs (e.g. vitamin-enhanced rice). Yet developed countries generally consume these foodstuffs in a processed form, and then it is remarkably cheaper to add the vitamins etc in the processing phase.[108]

Intense debate on the issues of genetically modified foodstuffs will, no doubt, continue in Europe for quite a while. Yet it might be the so-called white, industrial biotechnology that actually brings about more dramatic changes in agriculture than green biotechnology – away from foodstuffs, and towards growing raw materials for industry instead.[109]

Several companies are already in the business of „designing" animals and plants in order to turn them into therapeutic proteins production „factories". For example, *GTC Biotherapeutics* (USA) uses transgenic goats to produce monoclonal antibodies;[110] *Epicyte* (USA) produces the antibodies from maize.[111] Both technologies are a great deal cheaper than bioreactors, and their bulk production is very easy and inexpensive.[112]

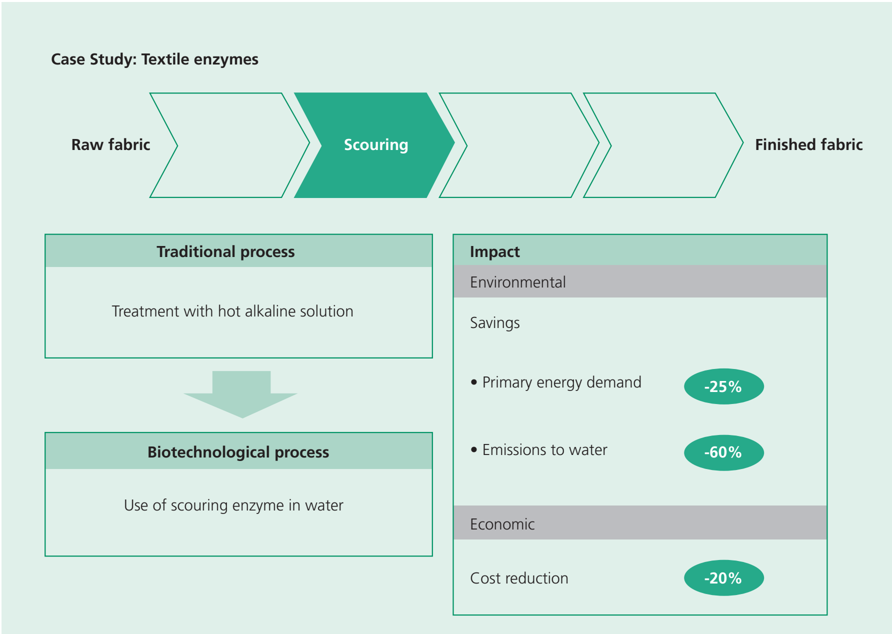
2.3.3. White biotechnology

Biotechnology has been used for developing diverse applications for industry for many years now. In 1988 a Danish company Novozymes placed on the market the first transgenic enzyme for detergents. Novozymes proclaims on its website that "*Enzymes are the miracle workers of both nature and industry, changing the world into a better place to live*."[113] Today Novozymes is the world leader in enzymes production.[114] Enzyme-catalysed processes have always been a much more effective method for generating molecules than traditional chemistry. It is only now, however, that the development of technology has reached the stage where it allows for the use of enzymes to create not only expensive products like drugs, but also consumer chemicals, and it is plastic and fuels that appear the most promising fields for the use of enzymes over the next decade.[115]

Above all, biopolymers are environmentally friendly since their production does not, in effect, have any consequence for global climate change. They are also biodegradable and facilitate productivity increase (see the examples below on textile enzymes and consumer chemicals).[116]

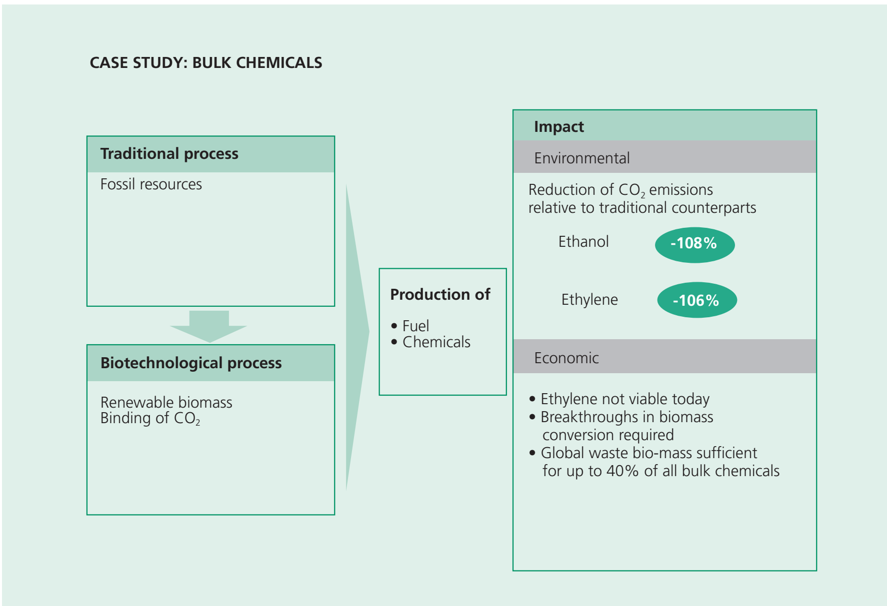
108 "Survey: Biotechnology", *The Economist*, 27.03.2003, http://www.economist.com/science/displayStory.cfm?story_id=1647556.
109 *Ibid.*
110 See http://www.transgenics.com/.
111 See http://www.epicyte.com/.
112 "Survey: Biotechnology", *The Economist*, 27.03.2003, http://www.economist.com/science/displayStory.cfm?story_id=1647556.
113 http://www.novozymes.com/; See also "Sea of Dreams", *The Economist*, 29.04.2004, http://www.economist.com/science/displaystory.cfm?story_id=2628644.
114 "Survey: Biotechnology", *The Economist*, 27.03.2003, http://www.economist.com/science/displayStory.cfm?story_id=1647556.
115 See *White Biotechnology: Gateway to a More Sustainable Future*, EuropaBio, 2003, http://www.mckinsey.com/clientservice/chemicals/pdf/BioVision_Booklet_final.pdf.
116 "Survey: Biotechnology", *The Economist*, 27.03.2003, http://www.economist.com/science/displayStory.cfm?story_id=1647556. See also National Research Council of Canada, *A Research Report of the Science and Technology Foresight Pilot Project: A Partnership of Federal S&T Organizations*, 2003.

Figure 13. **Productivity of textile enzymes.**



Source: *White Biotechnology: Gateway to a More Sustainable Future*, EuropaBio, 2003, http://www.mckinsey.com/clientservice/chemicals/pdf/BioVision_Booklet_final.pdf.

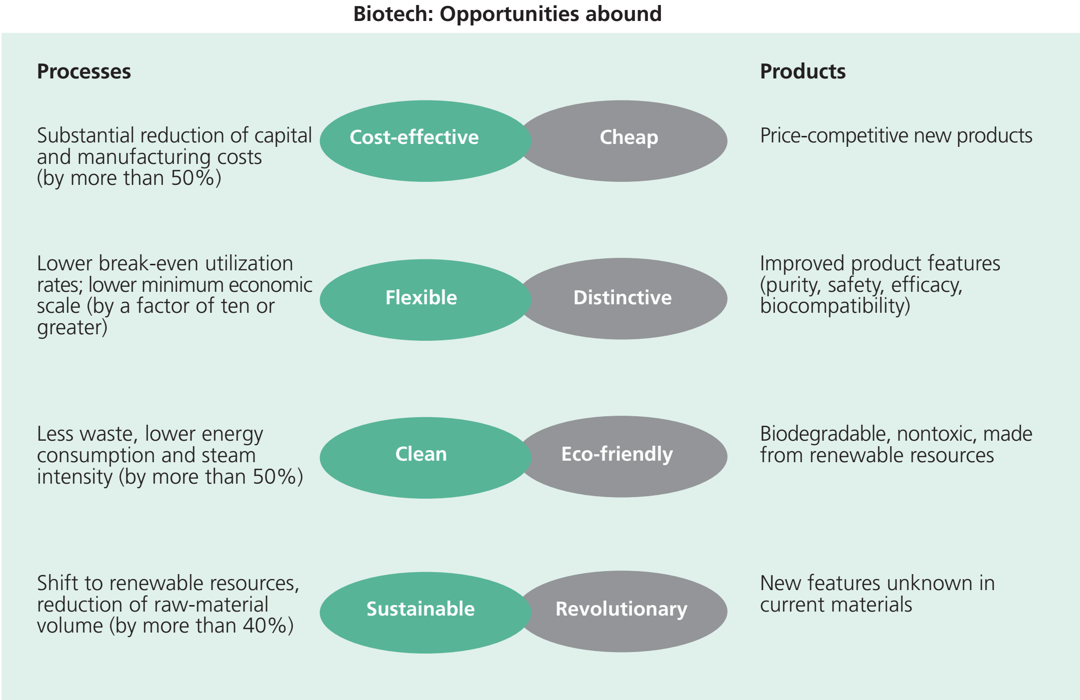
Figure 14. **Productivity of consumer chemicals.**



Source: *White Biotechnology: Gateway to a More Sustainable Future*, EuropaBio, 2003, http://www.mckinsey.com/clientservice/chemicals/pdf/BioVision_Booklet_final.pdf.

Then again, the opportunities offered by biotechnology to cut costs and create clean production technologies and products may also lead to a revolution in renewable natural resources, which could reduce the usage of natural resources in industry by as much as 40% (see Figure 15).

Figure 15. **Biotechnology based opportunities for more effective and environmentally friendly production.**

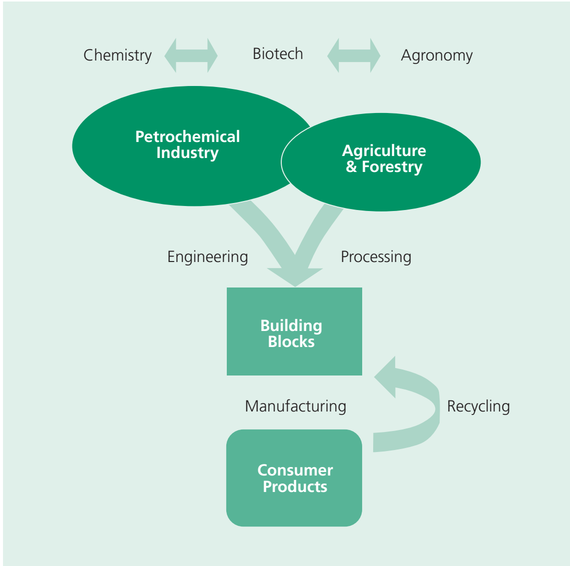


Source: Rolf Bachmann, Enrico Bastianelli, Jens Riese, and Wiebke Schlenzka, "Using plants as plants", *The McKinsey Quarterly*, 2000, 2, 92–99, http://www.fractal.org/Life-Science-Technology/Publications/Using-plants-as-plants.htm.

Since people have become more aware of what enzymes and micro-organisms can offer, industrial chemistry has gradually grown more influenced by biotechnology. Unlike contemporary chemistry, the future one will adopt new achievements immediately.[117] Both from the perspective of technology development and economic exploitation it is important to keep in mind that a chemical industry based on renewable natural resources is only able to operate successfully if achievements in biotechnology are accompanied by progress in the traditional industries of agriculture and forestry. (Figure 16)

[117] "Survey: Biotechnology", *The Economist*, 27.03.2003, http://www.economist.com/science/displayStory.cfm?story_id=1647556.

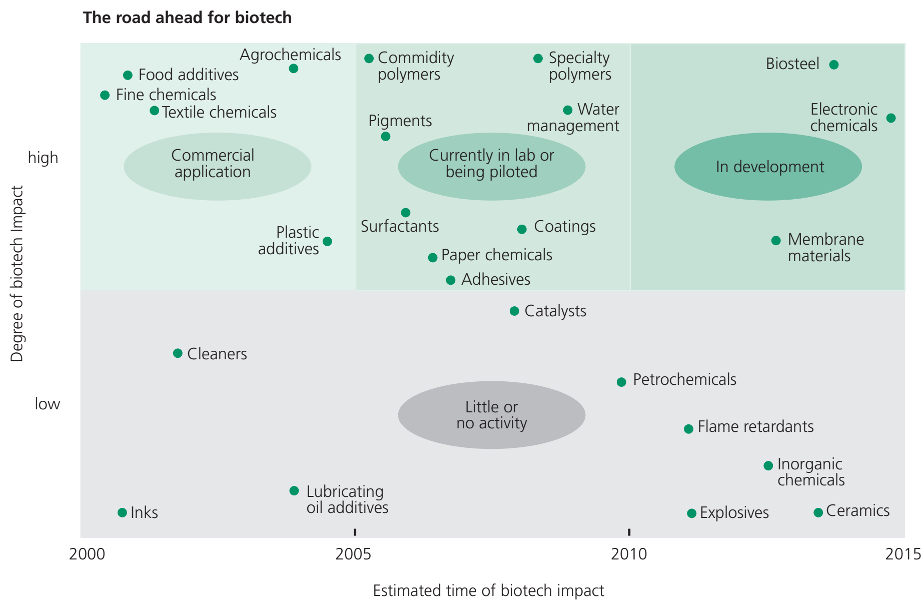
Figure 16. **Link between biotechnology and traditional industries.**



Source: *The Technology Roadmap for Plant/Crop-based Renewable Resources 2020*, Renewables Vision 2020, Executive Steering Group, 1999, http://www.oit.doe.gov/agriculture/pdfs/technology_roadmap.pdf.

Figure 17 provides a global overview of current applications, products being developed as well as potential future products and applications in the field of white biotechnology.[118] The US chemical industry anticipates multiple biotechnology based innovations – new applications both in products and technologies – by the year 2020.

Figure 17. **Status quo and future potential for the biotechnological development.**



Source: Rolf Bachmann, Enrico Bastianelli, Jens Riese, and Wiebke Schlenzka, "Using plants as plants", *The McKinsey Quarterly*, 2000, 2, 92–99, http://www.fractal.org/Life-Science-Technology/Publications/Using-plants-as-plants.htm.

118 See also *The Application of Biotechnology to Industrial Sustainability. A Primer*, OECD, 2001.

Figure 18. **Potential development paths in the US chemical industry up to 2020.**

Market Opportunities for New Materials (◆ Priorities)

- Cost-competitive polymers and composites for:
  - Transportation/automotive uses ◆◆◆◆◆◆
  - Infrastructure ◆◆◆◆◆◆
  - Hybrid materials, from structural nanomaterials to composites ◆◆◆◆◆
  - Medical/bioligical (implants, living polymers, materials that interface with biological systems, drug delivery systems, transparent chemically resistant material) ◆◆◆◆◆
  - Electrnics/opto-electronics ◆◆◆
  - Printed circuit boards (low absorption, cheaper, high T, low K)
  - Ultra low dielectric electrical insulation and circuits ◆◆◆
  - High-rise building construction ◆◆◆
  - Enhanced oil recovery ◆
  - Glass replacement for buildings and automobiles ◆
  - Lower-pressure separations (water purification, wastewater treatment) ◆
  - Electro-rheological applications (e.g., artificial hearts, automatic transmissions)
  - Thermal insulation
  - Light-weight, high-speed machinery
  - Barrier materials (agricultural, packaging)
  - Ballistic resistance
  - Low-cost housing/sanitation
  - Family housing/construction materials
  - Space construction materials
- Better poumeric textiles (e.g., tergets would be textiles comparable with natural fibers such as wool, cotton, silk and would be easily dyed and fabricated) ◆◆◆◆◆
- Light-weight powersources/energy storage and conversion ◆◆◆◆
- Adhesives to replace conventional metal fabrication techniques (e.g., structural adhesives to replace rivets) ◆◆◆
- High teperature proton exchange membranes ◆◆◆
- Organic materials with improved fire resistance ◆◆◆
- High volume applications such as thermopolymer elastomers (e.g.. tires) ◆◆
- Low-cost, high-barrier packaging ◆◆
- Coatings (paint, scratch resistance, decorative, protective, higher performance, more environmentallybenign)
- Coatings with zero emissions of volatiles
- Atmospheric carbon dioxide separation
- Aqueous high hardness glassy state coatings (rather than rubbery state at the end)
- Biodegradable polymers
- Photoelectric and electro-photic materials

Source: *Vision 2020 Chemical Industry of the Future. Technology Roadmap for Materials*, Materials Technology Committee, 2000, http://www.oit.doe.gov/chemicals/pdfs/materials_tech_roadmap.pdf.[119]

In the 1980s several developments were under way in Estonia to generate enzymes for biotechnology, including efforts to employ immobilised enzymes.[120] Today there is no industrial production, hence no real output. At the same time it is a globally widespread industry (enzyme-based test kits, enzymes for biotechnological conversion, starch-modifying enzymes, enzymes for environmental technology, enzymes as medications – e.g. to help digestion etc). There are two main branches – pure enzymes-chemicals, and various mixtures for selective conversion. The latter are cheaper and production costs are lower (e.g. used in cleaning/separation processes, which are generally low on productivity). Expensive ones are suitable for pharmaceutical industry.

Fermentation technology is also used in Estonia, especially in the food industry: lactic fermentation processes (yoghurt, fermented milk and cream products – enzymic coagulation as an alternative to acidification-based coagulation, vegetable souring etc), and the general production processes of bread, beer, wine and spirit. Likewise in the production of animal feedingstuffs – ensilage, additives in food and feed etc. In addition, other processes are used worldwide – microbiological synthesis of raw materials in the probiotics production cycle and pharmaceuticals (antibiotics); specific proteins are used for the production of various intracellular components etc.

[119] See also *Technology Vision 2020. The U.S. Chemical Industry*, American Chemical Society et al., 1996, http://membership.acs.org/I/IEC/docs/chemvision2020.pdf.

[120] Authors would like to extend their graditude to Andres Jagomägi for the following information.

2.4. Nanotechnology

Nanotechnology[121] as a name of a field of science and technology is rather new, but the earliest advances in nanotechnology (creating materials with desired features) were achieved by the mankind already in the 9th century when Caliphate potters created a technology for making multi-coloured lustre ceramics. This technology spread to Egypt, Persia and Andalusia already during medieval time, following the expansion of Islam Kingdoms, and then, in the 15th century, to Italy.[122]

Today's science is already well-informed about the fact that carbon, gold and many other substances reveal novel characteristics when manipulated on a nanometric scale. Some substances begin to conduct light or electricity, others become harder than diamond, the third one turns into an important catalyst to chemical reactions. Even more remarkable is how a relatively small amount of nanoparticles can change the characteristics and behaviour of significantly bigger substances or organisms – ranging from molecule-sized electronic devices to hypereffective fuel elements and the like.

The (potentially) revolutionary importance of nanotechnology for science and economy derives chiefly from three aspects:

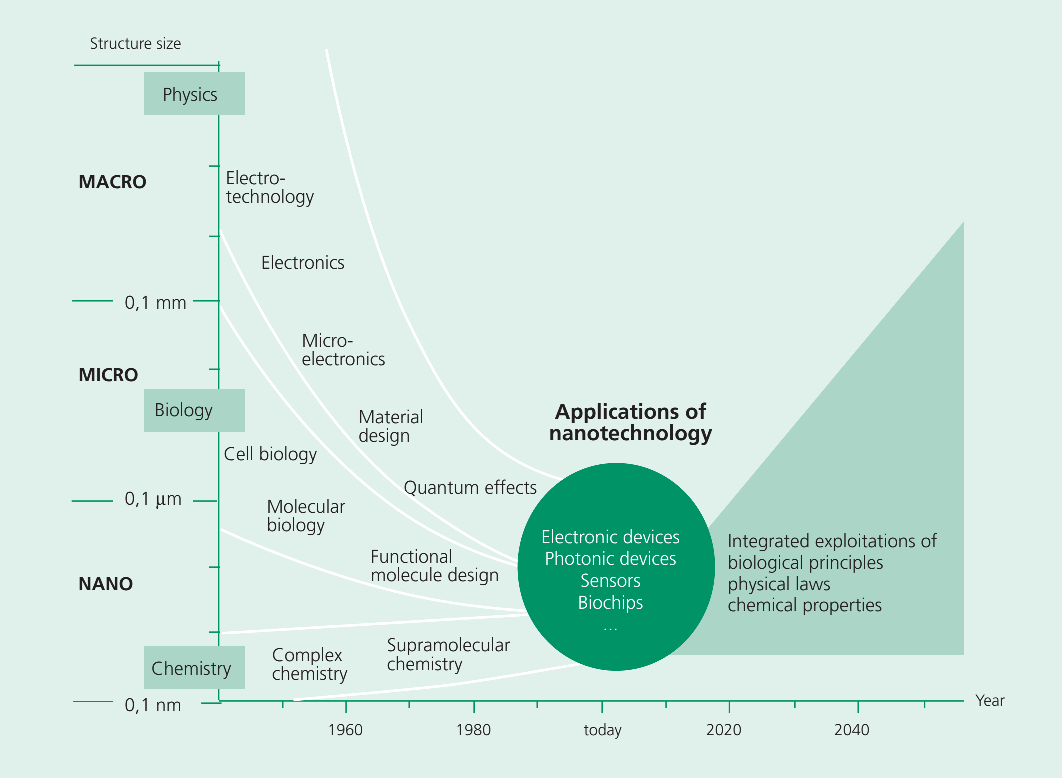
1) Nanotechnology's (anticipated) capacity and ability to handle both anorganic and organic substances and materials on the atom and molecule scale raises prospects for the emergence of completely new materials or materials with (qualitatively) novel characteristics. Nanotechnology can potentially transform the whole organic and anorganic world surrounding us.
2) Nanotechnology is multidisciplinary by its very nature: working on the nanoscale calls for merging physics, chemistry and biology as well as computer science. Therefore, developing nanotechnology and its various applications inevitably requires interdisciplinary science and learning.[123] This, again, implies a need for an enormous change in the whole contemporary system of research and education. On a broader scale it might also mean that the next technological revolution will start with precisely the convergence of different sciences and technologies. (Figure 8; for more see Ch 2.5)
3) In case nanotechnology turns out to be an economically profitable enterprise – and the above aspects point to plenty of reasons that speak for it – then it is likely that the development of nanotechnology itself will inevitably bring about colossal changes in economy, education and thereby also the social structure of our society.

121 Nanotechnology deals with structures on the scale of 0.1 (atom) to 100 nanometers (very big molecules). 1 nm = 10^{-9}m or 0.000000001 meters. On the contemporary definition of nanotechnology see Wolfgang Luther (ed), *Industrial Application of Nanomaterials – Chances and Risks*, VDI, Technology Center, Future Technologies Division, 2004, http://www.zukuenftigetechnologien.de/11.pdf, 5-7. See also „Nanotechnology and the Developing World", *PLoS Medicine*, 12.04.2005, http://medicine.plosjournals.org/perlserv/?request=get-document&doi=10.1371/journal.pmed.0020097.

122 Caliphate was one of the largest and most developed countries during the Middle Ages. Its capital was first located in Medina, and since 762 in Baghdad. In 1258 Baghdad was conquered by Mongol forces and the Capliphate ceased to exist. For a more detailed account of this technology see Cipriano Piccolpasso, *Li tre libri dell'arte vasaio*, 1557; "The oldest known nanotechnology dates back to the 9th century!", CNRS Institut des Sciences Chimiques Seine-Amont, 22.03.2004, http://www.newmaterials.com/news/680.asp.

123 See e.g. M. C. Roco and W. S. Bainbridge, "Converging technologies for improving human performance: integrating from the nanoscale", *Journal of Nanoparticle Research*, 4, 2002, 281-295, 282; and Greg Tegart, „Nanotechnology. The Technology for the 21st Century", http://www.nistep.go.jp/IC/ic030227/pdf/p2-3.pdf; but also Joachim Schummer, „Multidisciplinarity and Interdisciplinarity in Nanoscale Research", 2001, http://nanomr.dd6310.kasserver.com/downloads/s1/schummer_paper_final.pdf.

Figure 19. **Physics, biology and chemistry meet in nanotechnology.**



Source: VDI, Technology Center, Future Technologies Division, available as Greg Tegart, *Nanotechnology. The Technology for the 21st Century*, 2003, http://www.nistep.go.jp/IC/ic030227/pdf/p2-3.pdf.

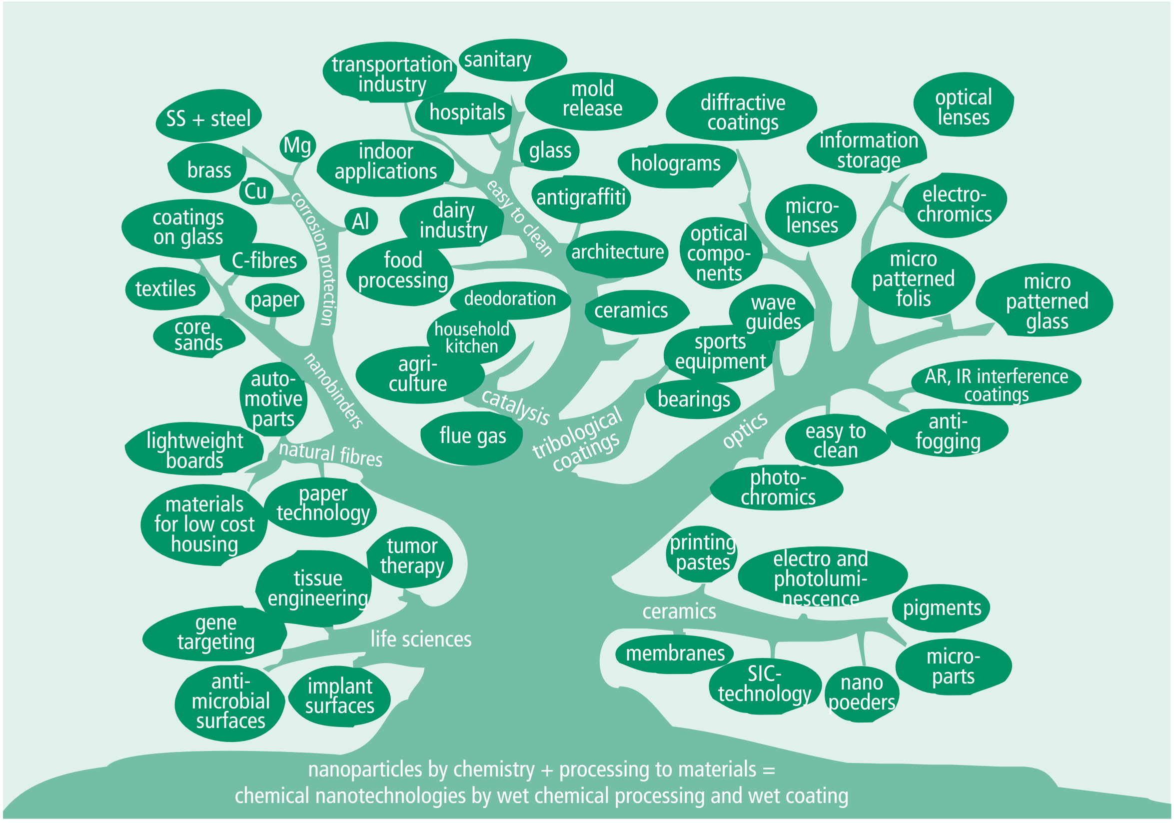
Its potential to generate materials with extremely durable, now still unimaginable qualities is but one significant economic motivation for the development of nanotechnology, albeit even here nanotechnology opens up massive prospects.[124] Figure 20 illustrates the potential impact of nanotechnology on various technologies and economic sectors.

Second, and today probably the most radical, therefore also the most far-fetched motivation is nanotechnology's potential to create nanorobots, universal molecular machines that are, among other things, capable of healing people, restoring cells and thereby making aging a reversible process; generating „personalised" chemical and biological weapons that attack only people with specific markers; or even creating new biological organisms.[125]

[124] For details see Wolfgang Luther (ed), *Industrial Application of Nanomaterials – Chances and Risks*, VDI, Technology Center, Future Technologies Division, 2004, http://www.zukuenftigetechnologien.de/11.pdf, 7-10.

[125] This is so-called synthetic biology, see for instance Philip Ball, „Synthetic Biology for Nanotechnology", *Nanotechnology*, 16, 2005, R1-R8; Jürgen Altmann, „Military Uses of Nanotechnology: Perspectives and Concerns", *Security Dialogue*, 35, 2004, 61-79. Fantasies of such universal robots have belonged with the development of nanotechnology since its very inception, see for instance the debate between Drexler and Smalley http://www.kurzweilai.net/news/frame.html?main=news_single.html?id%3D2700; then also http://www.thenewatlantis.com/archive/4/soa/nanotech.htm. At the same time, there is today fairly little of peer reviewed nanoscience that focuses on this segment, see for instance Ralph C. Merkle, „Molecular building blocks and development strategies for molecular nanotechnology", *Nanotechnology*, 11, 2000, 89–99.

Figure 20. **Potential impact of nanotechnology on other sciences and technologies.**



Source: *New Dimensions for Manufacturing. A UK Strategy for Nanotechnology*, DTI, 2002, 17, http://www.dti.gov.uk/innovation/nanotechnologyreport.pdf.

There are, in fact, two classic approaches to nanotechnology. The so-called top-down approach tries to minimise the structure of materials to nano scale: this essentially entails carving nanostructures out of larger objects. This approach is, above all, customary in nanoelectronics that is growing out of microelectronics, and in nanoengineering.[126] Bottom-up approach, on the other hand, involves manipulating individual atoms and molecules. This approach implies controlled or directed self-assembly of atoms and molecules, which is what enables the creation of nanorobots, molecular computers etc. The latter approach is actually much closer to the natural processes of chemistry and biology, where atoms and molecules come together to create structures such as crystals or cells. Hence it is just as well to say that the creation of a cell or a snowflake is nature's own nanotechnology at work.[127]

The somewhat science fiction-like future prospects aside, nanotechnology is, in fact, already present in today's economy. The total global demand for nanoscale materials etc was estimated at $7.6 billion in 2003, and is expected to grow 30% annually.[128]

This means that the annual industrial production in the nanotechnology sectors should exceed $1 trillion limit in 10-15 years from now, and the demand for nanotechnology workers should grow to about 2 million people by then.[129]

[126] See for instance *New Dimensions for Manufacturing. A UK Strategy for Nanotechnology*, DTI, 2002, 16, http://www.dti.gov.uk/innovation/nanotechnologyreport.pdf; and also *Vision 2020: Nanoelectronics at the centre of change: A far-sighted strategy for Europe,* Report of the High Level Group, European Commission, 2004, http://europa.eu.int/comm/research/industrial_technologies/articles/article_1190_en.html.

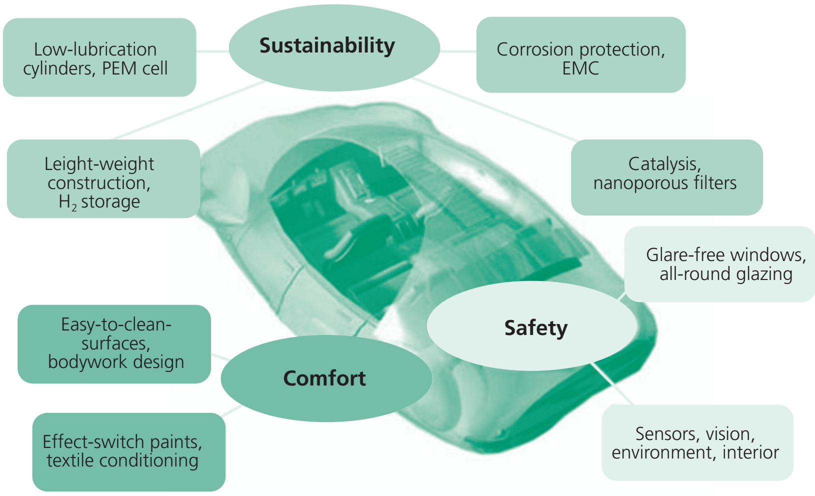
[127] *New Dimensions for Manufacturing. A UK Strategy for Nanotechnology*, DTI, 2002, 16, http://www.dti.gov.uk/innovation/nanotechnologyreport.pdf.

[128] *Nanotechnology: A Realistic Market Evaluation*, Business Communications Company, 2004, http://www.bccresearch.com/advmat/GB290.html.

[129] Mihail C. Roco, „Government Nanotechnology Funding: An international outlook", *NSF Nanoscale Science and Engineering*, 2003, http://www.nano.gov/html/res/IntlFundingRoco.htm.

Evaluation of the application readiness of various nanotechnology solutions suggests that it is the existing industries that nanotechnology solutions will most likely reach first. Figure 21 demonstrates the potential role nanotechnology could play in reviving car industry: from new H_2 storage space that facilitates the utilization of hydrogen fuel and corrosion-resistant surfaces to coatings that change colour according to owners preferences etc.

Figure 21. **Nanotechnology reviving traditional industry, NanoMobil.**[130]



Source: Volker Rieke and Gerd Bachmann, „German innovation initiative for nanotechnology“, *Journal of Nanoparticle Research*, 6, 2004, 435-446, 437.

Today's nanotechnology related activities can be roughly grouped into three areas: materials sciences; electronics and optoelectronics; and biomedicine.[131] Table 1 provides an overview of solutions and products from all these nanotechnology areas that are expected to undergo rapid development within the coming years and enter the market before long – from better storage of solar energy, various electronic displays, and self-cleaning surfaces to the so-called „lab-on-a-chip" diagnostic technologies.[132]

Table 1. **Today rapidly developing nanotechnology elements.**

Material sciences	Electronics and optoelectronics	Biomedicine
• New forms of carbon • Quantum dots and wires made by colloid chemistry • Nanostructured materials by self-assembly	• Semiconductor optoelectronics • Photonics • Memory and data storage • New methods for data input and output • Plastic electronics • Molecular electronics • New concepts in computing	• Drug delivery • Tissue engineering • The laboratory-on-a-chip

Source: Stephen Wood, Richard Jones, Alison Geldar, *The Social and Economic Challenges of Nanotechnology*, ESRC, 2003, 10-17.

130 NanoMobil is a nanotechnology programme of German Federal Ministry of Education and Research, http://www.bmbf.de/de/1846.php.

131 See more about the visions for nanomedicine http://www.nanomedicine.com; Laura Mazzola, „Commercializing nanotechnology“, *Nature Biotechnology*, 21, 2003, 1137-1143; C. A. Haberzettl, „Nanomedicine: destination or journey?“, *Nanotechnology*, 13, 2002, R9-R13.

132 *New Dimensions for Manufacturing. A UK Strategy for Nanotechnology*, DTI, 2002, 23, http://www.dti.gov.uk/innovation/nanotechnologyreport.pdf.

Over the coming decade we will probably witness the introduction of such products and technologies as targeted drug delivery, polymer electronics, various biomedical sensors to monitor patients' health status, significantly stronger materials used in the production of tools, artificially generated organs and implants etc.[133] (Table 2) One cannot go without also mentioning new nanotechnology based medications, new cost-saving ways of producing medications, or even new methods of treatment (e.g. in surgery). Equally important are new opportunities for energy and natural resource (incl. hydrogen fuel) production.[134]

Table 2. **Estimated timing of the realisation of some technological opportunities in nanotechnology.**

In 3 years	
	Selective bio nanosensors
	Specific drug delivery systems
	Nano-electronics based on miniaturized silicon devices
	Novel devices based on magnetic spin electronics
	Nanostructured materials as industrial catalysts
	Self-cleaning surfaces based on nanomaterials
In 10 years	
	Advanced medical diagnostics
	Targeted human cells for organ repair
	Single electron devices
	Optical computing
	Portable fuel cell and advanced battery
	Artificial photosynthesis

Source: Greg Tegart, „Nanotechnology. The Technology for the 21st Century", 2003, http://www.nistep.go.jp/IC/ic030227/pdf/p2-3.pdf.

When we take a look at the positions various countries or regions hold in nanotechnology in regard to both public sector funding as well as patents and publications, we see mostly the US, Western Europe and Japan in the lead in all of these aspects.[135]

[133] See also *Nanoscience and Nanotechnologies: opportunities and uncertainties*, Royal Academy of Engineering, Royal Society, 2004, http://www.nanotec.org.uk/finalReport.htm.

[134] See also the 10-15 year projections of potential developments presented by the National Research Council of Canada *A Research Report of the Science and Technology Foresight Pilot Project: A Partnership of Federal S&T Organizations*, National Research Council of Canada, 2003, 16.

[135] USA is also the leader in political support and regulation, see in particular http://www.nano.gov/ and http://www.nsf.gov/home/crssprgm/nano/; a concise assessment of current activities is provided in Mihhail C. Roco, „The US National Nanotechnology Initiative after 3 years (2001-2003)", *Journal of Nanoparticle Research*, 6, 2004, 1-10.

Table 3. **Worldwide government funding for nanotechnology R&D (million USD).**[136]

	1997	1998	1999	2000	2001	2002	2003	2004***
Western Europe	126	151	179	200	~225	~400	~650	~900
Japan	120	135	157	245	~465	~720	~800	~900
USA*	116	190	255	270	465**	697**	862**	960
Others	70	83	96	110	~380	~550	~800	~900
Total	**432**	**599**	**687**	**825**	**1535**	**2367**	**3122**	**3660**
% of 1997 level	**100%**	**129%**	**159%**	**191%**	**355%**	**547%**	**722%**	**847%**

Source: Mihhail C. Roco, „The US National Nanotechnology Initiative after 3 years (2001-2003)“, *Journal of Nanoparticle Research*, 6, 2004, 1-10, 2.

The world's leading industrial and technology countries have already launched extensive nanotechnology programmes that target basic research and applications as well as commercial exploitation. In all probability we will see nanotechnology having major impact on technology and economy only in another 15-20 years time, but this impact will presumably have revolutionary proportions and will span from agriculture and other traditional industries all the way up to high technology.

Yet the large-scale (with a budget of more than $100 million) nanotechnology R&D programmes are today still very young even in the leading countries. The US National Nanotechnology Initiative was announced in 2000. In 2001 similar programmes followed in Japan and Korea, and in 2002 also in Germany and Taiwan.[137]

According to publications and patents per inhabitant, several European countries appear to have rather promising positions in nanotechnology. Even the new member states of the European Union are among the top 50 most active countries in relation to their share of world's nanotechnology publications (1997-1999). And Estonia ranks 50th.[138] (Table 4)

136 ‚Western Europe' includes all member states of the European Union as well as Switzerland; ‚others' includes Australia, Canada, China, Central and Eastern European countries as well as the countries of former Yugoslavia, Korea, Singapore, Taiwan etc * A financial year begins in USA on October 1 of the previous calendar year, six months before in most other countries. ** Denotes the actual budget recorded at the end of the respective fiscal year. Estimations use the nanotechnology definition as defined in the US National Nanotechnology Initiative – this definition does not include Micro-Electro-Mechanical Systems, and includes the publicly reported government spending. *** Denotes initial data. See also Mihhail C. Roco, „Government Nanotechnology Funding: An international outlook“, *NSF Nanoscale Science and Engineering*, 2003, http://www.nano.gov/html/res/IntlFundingRoco.htm; and *Towards a European strategy for nanotechnology*, European Commission, COM(2004) 338 final, 12.5.2004.

137 M. C. Roco, „Broader societal issues of nanotechnology“, *Journal of Nanoparticles Research*, 5, 2003, 181-189, 183. About German initiatives see Volker Rieke and Gerd Bachmann, „German innovation initiative for nanotechnology“, *Journal of Nanoparticle Research*, 6, 2004, 435-446; Taiwan, though a relatively smaller country as compare to the ones mentioned above, has also developed very comprehensive schemes for developing and financing nanotechnology, see C. K. Lee et al., „A catalyst to change everything: MEMS/NEMS – a paradigm of Taiwan's nanotechnology program“, *Journal of Nanoparticle Research*, 4, 2002, 377-386.

138 *Third European Report on Science and Technology Indicators*. Brussels: European Commission, 2003, 394.

Table 4. **Nanotechnology publications and patents per inhabitant.**[139]

Normalized publications (1997-99) per million inhabitants		Normalized patents EPO&PCT (1991-99) per million inhabitants	
150.2	Switzerland	12.2	Switzerland
91.4	Israel	4.4	Germany
73.5	Sweden	3.9	Israel
61.5	Germany	3.8	Belgium
56.9	Denmark	3.6	France
56.8	Singapore	3.5	USA
52.6	Austria	2.4	Netherlands
50.0	France	2.4	Sweden
48.3	Finland	2.3	Japan
47.7	Netherlands	1.8	UK
46.4	Japan	1.5	Canada
43.6	Belgium	1.3	Australia
42.7	UK	1.0	Austria
39.2	USA	0.5	Italy
43.6	Slovenia	0.3	Spain

Source: Ramón Compañó and Angela Hullmann, „Forecasting the development of nanotechnology with the help of science and technology indicators“, *Nanotechnology*, 13, 2002, 243-247, 246.

The fields with the biggest share in nanotechnology patents are chemistry, biomedicine and semiconductors. Nanotechnology is already today very closely tied to all these fields in practical applications. (Table 5)

139 Publications represent the data from Science Citation Index, patents from the European Patent Office and Patent Cooparation Treaty. For a comparison see also European Commission, *Third European Report on Science & Technology Indicators 2003*, http://www.cordis.lu/indicators/third_report.htm, and Dora Marinova and Michael McAleer, „Nanotechnology strength indicators: international rankings based on US patents“, *Nanotechnology*, 14, 2003, R1-R7, and for information about nanotechnology patents registered in the US Patent and Trademark Office see Huang et al., „International nanotechnology development in 2003: Country, institution, and technology field analysis based on USPTO patent database“, *Journal of Nanoparticle Research*, 6, 2004, 325-354, 331.

Table 5. **Leading technology fields relative to the number of patents filed in the US Patent and Trademark Office, 1976-2002.**

Rank	Technology field	Number of Patents	Average Patent Age
1	435 Chemistry, molecular biology and microbiology	7837	7.28
2	514 Drug, bio-affecting and body treating compositions	6364	7.84
3	424 Drug, bio-affecting and body treating compositions	4760	7.05
4	428 Stock material or miscelaneous articles	3847	8.23
5	250 Radiant energy	3783	10.14
6	530 Chemistry: natural resins or derivatives, peptides or proteins, lignins or reaction	3772	7.80
7	536 Organic compounds - part of the class 532-570 series	3701	5.90
8	438 Semiconductor device manufacturing process	3584	6.31
9	257 Active solid-state devices (e.g. transistors, solid-state diodes)	3480	7.93
10	427 Coating processes	3179	9.10
11	436 Chemistry: analytical and immunological testing	2941	9.87
12	430 Radiation imagery chemistry process, compostion, or product thereof	2883	9.66
13	359 Optics: systems (including communication) and elements	2743	8.77
14	356 Optics: measuring and testing	2556	10.20
15	422 Chemical apparatus and process disinfecting, deodorizing, preserving, or sterilizing	1665	9.05
16	204 Chemistry: electrical and wave energy	1660	9.65
17	252 Compositions	1647	10.48
18	524 Synthetic resins or natural rubbers - part of the class 520 series	1515	9.01
19	546 Organic compounds - part of the class 532-570 series	1503	8.62
20	210 Liquid purification or separation	1451	9.48
	Average	**3243.55**	**8.62**

Source: Huang *et al.*, „International nanotechnology development in 2003: Country, institution, and technology field analysis based on UPTSO patent database“, *Journal of Nanoparticle Research*, 6, 2004, 325-354, 340.

Then again, the very fact that the development of nanotechnology is so entwined with many vitally important fields such as medicine, environment, security, as well as with economically critical fields such as semiconductors and chemistry, makes it imperative to exercise great caution in introducing nanotechnology solutions. This is precisely why already today the analysis of ethical, legal and social aspects has emerged as a fairly significant facet of nanotechnology. Research in social impact assessment of both bio- and nanotechnology will most likely gain considerable importance in an attempt to avoid the setbacks experienced in biotechnology during the placement on the market of genetically modified organisms.[140]

[140] For an overview see Anisa Mnyusiwalla et al., „'Mind the gap': science and ethics in nanotechnology", *Nanotechnology*, 14, 2003, R9-R13.

2.5. Convergence of information, bio- and nanotechnologies

Current techno-economic paradigm is mostly based on information and communication technology, which means that information technology sector shows highest growth rates in productivity, and this trend will spread into other sectors along with information technology. Bio- and nanotechnology, on the other hand, are only at the beginning of their paradigm – if and when they actually become engines of a paradigm is not at all established, because we do not know **yet** what are going to be these very specific technological solutions (like *Intel* microprocessor many years ago) that will make these technologies (either independently or by way of integration) penetrate virtually every other economic sector. The prerequisite to a paradigm change is that the new technological solution or the group of solutions is cheap, that it can be produced fast and in large quantities, and that it is widely applicable.[141]

Besides, we cannot expect the bio- or nanotechnology "microprocessor" to just come out of blue sky at a random place and in a random field – just like over the past 200 and plus years it was never the technology that directed the development of economy, but the economy and entrepreneurs, above all, that picked new technologies[142] (see also Ch 1.3). Thus, it is the technological bottlenecks of today's technologically advanced companies that most of the investments are targeted at. This relates to not only bio- and nanotechnology companies, but all the sectors more or less closely related to these two as well.

However, since it is not established yet when and what exactly is to be expected of the radical technological innovations in the fields of bio- and nanotechnology, then there are extremely high risks involved,[143] which is why appropriate supporting strategies and policies are so badly needed. This is precisely how the US has been most successful in developing its economy in line with the paradigm framework with most of the government investments into research and development made at the gestation and early stages of a new paradigm, and significantly decreased by the time the paradigm has evolved to the point where private sector is already able to earn very big profits and carry on the investment.[144] (For more details see Ch. 1.2, incl. Figure 4) For example, in the 1970s the US federal government was in effect the only major client of the emerging computer industry, whereas today government role in the total turnover of this industry is negligible.[145]

141 Carlota Perez, "Structural Change and the Assimilation of New Technologies in the Economic and Social System", *Futures*, 15, 357-375, 1983.

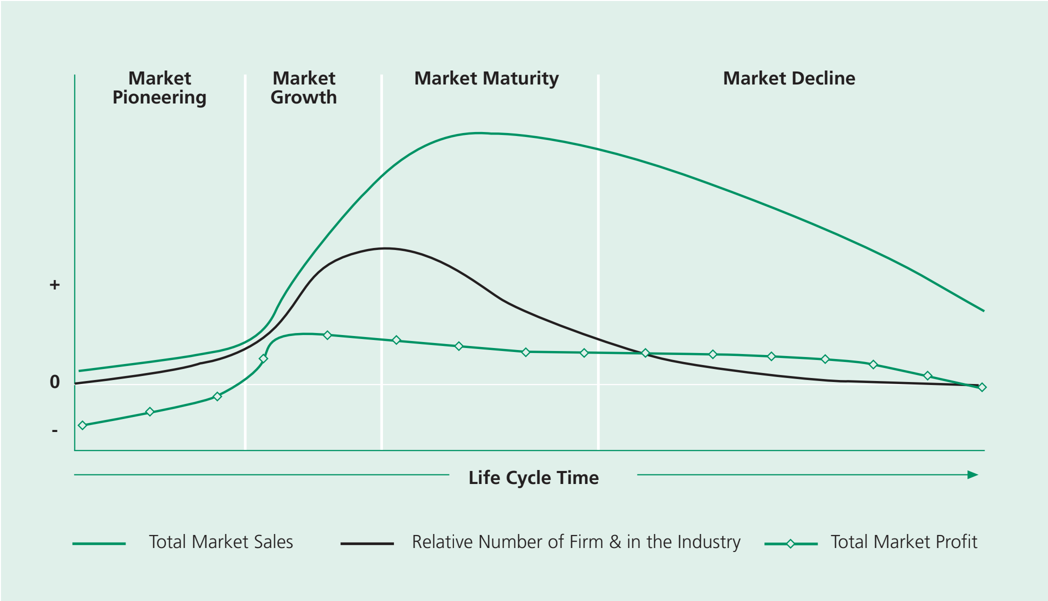
142 See also: Wiebe Bijker (ed), *The Social Construction of Technological Systems*, Cambridge, MA, MIT Press, 1994.

143 There are no "full guarantees", for sure. Nuclear energy was considered an "almighty" technology with a great potential to change the whole world in quite the same way after the World War II. Admiral Lewis Strauss, chairman of the US Atomic Energy Commission believed in the 1950s that nuclear energy will become altogether "too cheap to meter". Yet for multiple reasons, incl. relatively poor safety systems and lack of social acceptability of this technology, these predictions were never fulfilled.

144 About the cost-effectiveness of public sector investments into research and development see e.g. Ammon J. Salter and Ben R. Martin, „The economic benefits of publicly funded next term basic research: a critical review", *Research Policy*, 2001, 30, 3, 509-532.

145 About close competition between the US and Japan on the computer industry market in the 1950-1960s and about the governments' active role in nurturing their domestic information technology industries see also Hideaki Miyajima *et al*, *Policies for competitiveness, Comparing business-government relationships in the 'Golden Age of Capitalism'*, Oxford University Press, 1999.

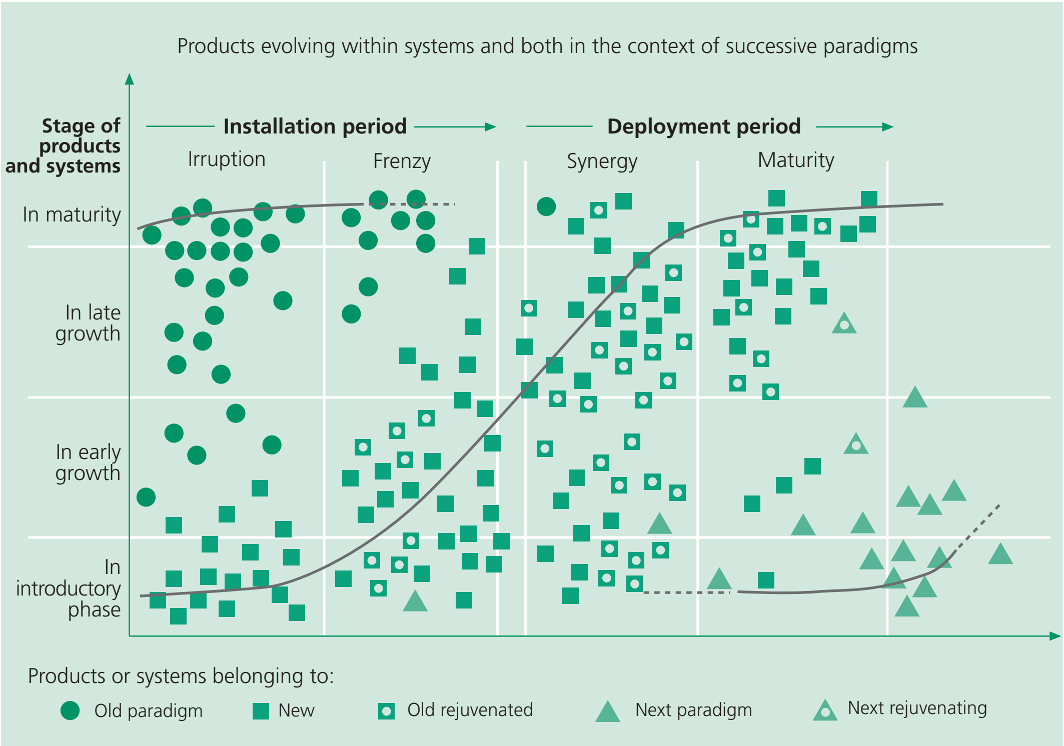
Figure 22. **Product life-cycle: sales, relative number of firms and profitability.**



Source: Cundiff *et al. Fundamentals of Modern Marketing*. Englewood Cliffs, Nueva Jersey, Prentice–Hall, 1973. Referenced in Carlota Perez.

History of economy and technology has taught us that in the coming decade life will most likely continue along the lines of information technology canon. Then again, rapid dissemination of knowledge and technology (especially in the developed world) means that the productivity gained from a certain technology cannot grow endlessly. Its slowdown occurs in inverse proportion to the dissemination of technology, since competition is growing fiercer and the potential of the relevant technology is becoming exhausted. In this situation a renewed growth in productivity is derived from a new technology and its corresponding paradigm. It is already apparent how new bio- and nanotechnologies are more and more vigorously infiltrating the sphere of information technology, and the other way round. This will lead to a change of techno-economic paradigm as a result of either the convergence of information technologies and/or independent dramatic developments in bio- and nanotechnology (see also Ch. 1.2). (Figure 23)

Figure 23. **Evolution of techno-economic paradigms.**



Source: Carlotta Perez, from the seminar in Tallinn on 24-25.4.2003.

The trends described above imply that technology policy must be based on a sound analysis of global markets. It is now high time to aggressively grow a solid competence base in bio- and nanotechnology. Yet when you ask people in the companies currently operating in Estonia about priorities or "needs of the economy", they clearly place the priorities elsewhere due to current structure of the economy (and relevant political power positions) etc. Analysing developments in other countries makes it pretty clear that free market is not capable of making the right decisions here.

In Europe as well as other places most of the private sector research and development expenditure still flows into relatively few economic sectors, and the four largest among them – automobiles and parts, pharmaceuticals and biotechnology, IT hardware, and electronic and electrical equipment account for 67% of global investment into research and development. (Table 6)

Table 6. **European Union and Non-European Union R&D investments by sector, data from 2003.**[146]

	European Union		Non-European Union	
	% of all sectors	R&D / sales	% of all sectors	R&D / sales
Automobiles and parts	23.8	4.6	15.7	4.1
Pharmaceuticals and biotechnology	17.0	15.2	18.5	15.1
IT hardware	12.4	15.6	22.9	8.6
Electronic & electrical equipment	10.3	6.5	10.9	5.7
Chemicals	7.2	4.2	4.2	3.8
Aerospace & defence	6.8	8.0	2.1	2.7
Engineering & machinery	4.6	2.5	2.5	2.8
Telecommunication services	2.8	1.0	2.0	2.5
Software & computer services	2.6	12.8	7.8	10.0
Oil & gas	1.9	0.3	1.2	0.5
Remaining 21 sectors	10.6	1.5	12.2	2.1
Total (31 sectors)	**100**	**3.2**	**100**	**4.5**

Source: *Monitoring Industrial Research: The 2004 EU Industrial R&D Scoreboard*, vol. 1, European Commission, 2004, 6.

All the "pictures" presented above are very technology deterministic and describe only some of the possibilities made available by the development of science and technology. Technological feasibility does not, however, mean that the reality will actually follow these exact paths or that people will buy into everything that is made possible by technology. Described trends in the development of research and technology should, by no means, be viewed as conclusive and unrivalled. They reflect the expected developments in the demand dynamics of global economy, and visions that today's technology leaders have suggested for the future of research and development and that people work really hard to realise. From the point of view of Estonian economy and society, these are pretty much exogenous developments that occur autonomously from whatever we do anyways. The critical questions are whether and how do we prepare ourselves for these developments.

Yet these developments do not constitute a mandatory list that definitely has to be executed to the full. Instead, a small country should view them as a background or a description of what is possible and likely to happen in the world of science and technology, against which to draw up its own strategies. They do, however, also give us much needed pointers that can be used in further analysis while seeking solutions for the socio-economic challenges Estonia will face in the future. Yet in reality it is still the people and their today's strategic preferences that are at the centre of attention, and those are influenced by specific surroundings as well as social, economic and other aspects of various technologies among other things. Therefore, it is important to take into account the following risks that a bio- and nanotechnology focus raises:

1. **timing of the investments and unrealistic expectations** – radical technological breakthroughs (miracles) usually take much more time to materialise than initially anticipated. Compare, for instance, how only a few years ago all those ardent expectations about gene technology and personalised medicine still seemed so feasible. Unstable financial markets, possible anxiety among the public, difficulties in launching mass production can all cause several years of delay in the expected breakthroughs in medical and energy technology as well as other fields.

[146] Table 6 presents data on the top 500 R&D-investing companies in the European Union and another 500 outside the European Union. The sector classification presented in the table follows that of *Financial Times Stock Exchange index*; "R&D / Sales ratio" denotes the ratio of company's R&D investment to its net sales.

2. **possible (suspected) environmental hazards / social acceptability issues etc associated with new bio-nanotechnologies and materials** – our surrounding environment, including air and water, are filled with natural molecules and nanoparticles. If any of the new particles that humans have created with the help of bio- or nanotechnology should turn out to be hazardous to the surrounding environment, this whole field might encounter setbacks comparable to what genetically modified foodstuffs and nuclear energy have had to face earlier.

In case Estonia has faith in the above-mentioned visions of the developments in bio- and nanotechnology, then we have to be able to direct our resources today into the rapid "production" (importing) of specialists for those specific fields. In case we believe in something else, we should invest accordingly. Whatever choices we make, it will mean that at least in that area Estonian scientific competence will have to be raised above the average level of the broader field and to the very cutting edge. This is the only way to secure top quality higher education and degree studies. It is also the only way to create a basis for the influx of first-rate foreign investments into the respective areas etc.

Yet, this also touches upon much broader issues – from vocational education to the financing of enterprise support schemes. Those who prefer it that way could actually say that it is "the invisible hand" that invests like crazy in information technology industry in one decade only to do the same with biotechnology the next decade.

In the end, what matters is the principle that: **only government is capable of bearing the risks critical to economic development (for instance, by investing today into biotechnology), and doing this in a prudent and consistent manner (for instance, by modernising the existing chemical industry with the help of biotechnology etc). The most important lesson is that the risks can never be divided between the high technology and the so-called traditional sectors, but must be borne together.**

3. Socio-economic challenges facing Estonia

3.1. External balance

Over the past years economies of the Baltic states have grown remarkably fast in comparison with the economic stagnation that occurred in Western Europe and North America, and have exceeded both GDP and productivity growth indicators of developed countries by several percentage points every year. Estonia's most important macroeconomic indicators are generally viewed as showing good results. For instance, Estonia registered the highest government surplus of 3.1% (in 2003) and the lowest ratio of government debt to GDP (4.9% of GDP in 2004) among the European Union member states.[147] At the same time, in recent years, analysts of various organisations (incl. Bank of Estonia, IMF, Swedbank, ETLA etc) have highlighted the high current account deficit,[148] which is not sustainable in medium or long term according to IMF estimates,[149] as one of the main threats to Estonian economy. European Central Bank recommends that Estonia maintain its current budgetary discipline while simultaneously curbing growth in wages and loans. The Bank of Estonia (central bank of the Republic of Estonia), on the other hand, proposes that we curb the loans provided for domestic consumption and focus more on facilitating exports.[150]

Some imbalance in external trade (and current account) is often considered natural for developing countries due to sizeable investments needed for modernising their economies, and the expected increase in exports growth in the long run. Yet Estonia's external trade has shown no signs of balancing over the past 10 years. A simple comparison of industrial production, import and export indicators demonstrates that in 2000 the volume of Estonian produce exceeded domestic consumption only in fishery products, various wood processing products (incl. furniture and newspapers), lime and cement. In all other commodity groups domestic consumption surpassed Estonian production. In other words, Estonia's domestic demand exceeds the value added by local production, which is reflected in the steady and rising current account deficit. (Table 7)

Table 7. **Estonia's GDP and balance of payments 1993-2004 (in million EEK).**[151]

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005*
GDP	22820.3	31349.4	43060.6	55895.4	68576.1	78027.6	81775.9	92937.7	104459.0	116915.3	127333.8	141493.4	164918.4
Change, constant prices %		-1.6	4.5	4.4	11.1	4.4	0.3	7.9	6.5	7.2	6.7	7.8	9.8
Trade balance	-1925.0	-4615.9	-7615.5	-12288.2	-15652.8	-15725.5	-12096.9	-13143.6	-13783.9	-17995.6	-21483.0	-24803.2	-23057.7
Exports	10762.7	15828.5	19428.2	21833.4	31846.5	37786.3	36995.2	56345.9	58667.1	58333.6	63599.8	75061.0	98715.3
Imports	-12687.7	-20444.4	-27043.7	-34121.6	-47499.3	-53511.8	-49092.1	-69489.5	-72451.0	-76329.2	-85082.8	-99864.2	-121775.9
Services	997.1	1362.7	4330.3	6245.0	8232.7	8049.3	8341.5	9574.6	10160.2	9677.4	11782.6	13738.5	12552.7
Exports	4434.3	6657.0	10022.9	13352.8	18366.7	20804.0	21951.9	25485.8	28866.5	28279.7	30819.9	35591.3	39697.2
Imports	-3437.2	-5294.3	-5692.6	-7107.8	-10134.0	-12754.7	-13610.4	-15911.2	-18706.3	-18602.3	-19037.3	-21852.8	-27114.5
Goods and services	-927.9	-3253.2	-3285.2	-6043.2	-7420.1	-7676.2	-3755.4	-3569.0	-3623.7	-8318.2	-9700.4	-11064.7	-10504.9
Current account	279.0	-2145.6	-1810.6	-4806.9	-7810.2	-6760.2	-3607.7	-5093.4	-5889.5	-11882.9	-15401.9	-17 963.0	-17285.8
% of GDP	1.2%	-6.8%	-4.2%	-8.6%	-11.4%	-8.6%	-4.4%	-5.5%	-5.6%	-10.2%	-12.1%	-12.7%	-10.5%

NB! The GDP data for 2005 is based on preliminary calculations of the Statistical Office of Estonia.
Source: Eesti Pank, http://www.eestipank.info, Statistical Office of Estonia, http://www.stat.ee, March 2006; calculations by the authors.

147 *Euro-indicators News Release 117/2004*, Eurostat, 23.09.2004, http://epp.eurostat.cec.eu.int/cache/ITY_PUBLIC/2-23092004-AP/EN/2-23092004-AP-EN.PDF, and *Euro-Indicators News Release 39/2005* Eurostat, 18.03.2005, http://epp.eurostat.cec.eu.int/pls/portal/docs/PAGE/PGP_PRD_CAT_PREREL/PGE_CAT_PREREL_YEAR_2005/PGE_CAT_PREREL_YEAR_2005_MONTH_03/2-18032005-EN-AP.PDF.

148 In the 2nd quarter of 2004 Estonia's current account deficit was 20.4% of GDP, in Latvia 16.7%, in Lithuania 10.6%. Even though circumstances are not at all the same, many other Central and Eastern European Countries are also experiencing significant current account deficit. See http://www.economagic.com. The record high deficits in the first half of 2004 may have been inflated by the pre-accession import boom, but a current account deficit exceeding even 5% of GDP is generally considered dangerous for economic sustainability. See e.g. Jason Furman and Joseph E. Stiglitz, „Economic Crises: Evidence and Insights from East Asia", in William C. Brainard and George L. Perry (eds), *Brookings Papers on Economic Activity, 1998:2*, Brookings Institution Press, 1999, 1-114, http://brookings.nap.edu/books/0815711956/html/.

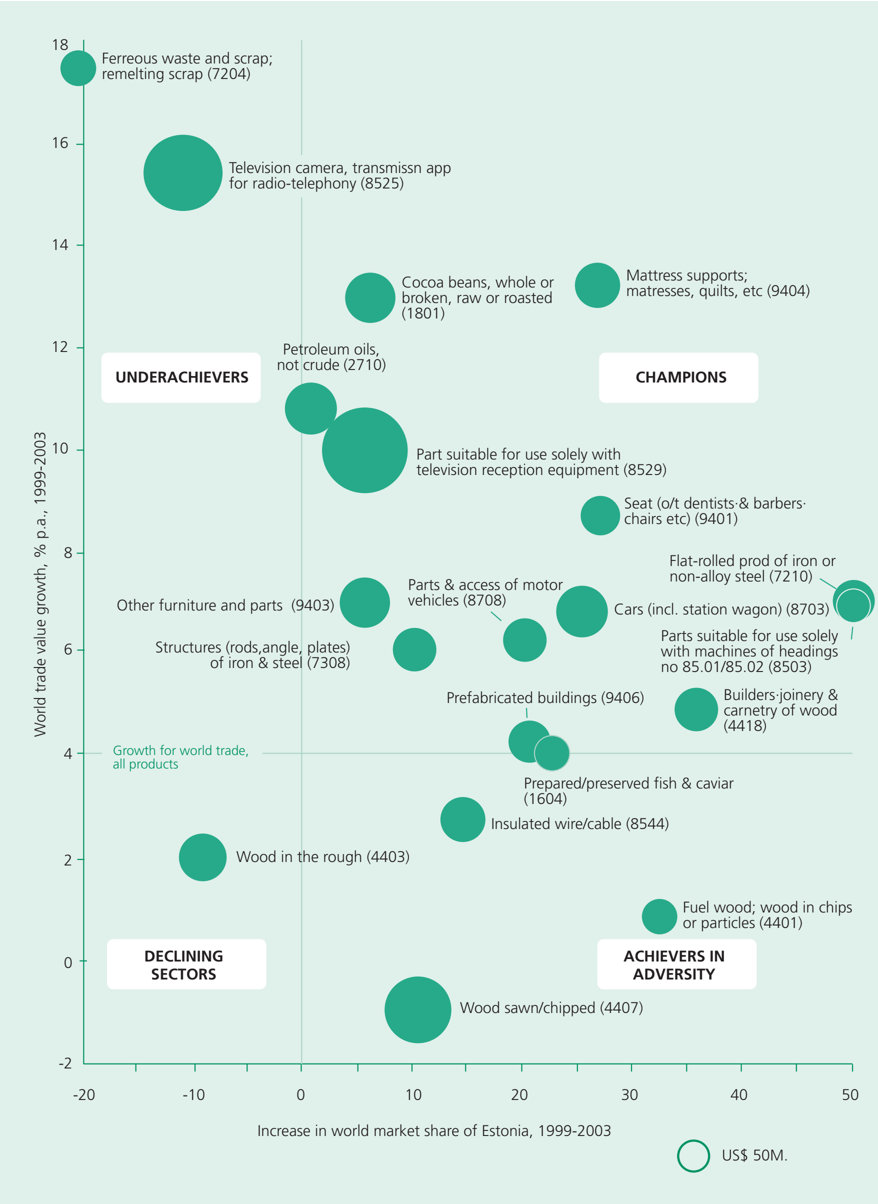
149 Robert Burgess, Stefania Fabrizio and Yuan Xiao, *Competitiveness in the Baltics in the Run-Up to EU Accession, IMF Country Report No 3/114*, April 2003, 5, http://www.imf.org/external/pubs/ft/scr/2003/cr03114.pdf.

150 *Convergence Report 2004*, European Central Bank, Frankfurt, 2004, 44; Vahur Kraft's presentation in Riigikogu, 12th October 2004.

151 In addition to exceptionally high foreign trade deficit, in 2003 income deficit also amounted to a record 7.9 million EEK, i.e. 46% higher than the year before. Inflow of revenues increased only by 1% that year. 75% of the revenue deficit derived from reinvested earnings. See Eesti maksebilansi aastaraamat 2003 [Balance of Payments Yearbook 2003], Eesti Pank 2004, 20, http://www.bankofestonia.info/pub/et/dokumendid/publikatsioonid/seeriad/mbaasta/_2003/.

Estonia's imports are mostly dominated by various machinery and equipment (incl. notably information and telecommunication equipment), means of transportation, chemical and food products. In addition to the transit of liquid fuel, which plays a significant role in both imports and exports,[152] most important Estonian exports include telecommunications equipment, raw wood, sawn timber and furniture as well as foodstuffs. It is noteworthy that the global market has seen a rapid increase in both fuels and electronics markets over the past years, whereas growth of Estonian market share has been considerably modest. (Figure 24)

Figure 24. **Estonian export portfolio 1999-2003.**



Source: *Perspectives on Experience,* Boston Consulting Group, Boston, MA, 1974; *Estonia: Country Profile*, UNCTAD/WTO International Trade Centre, http://www.intracen.org, February 2005; adjustments by authors.

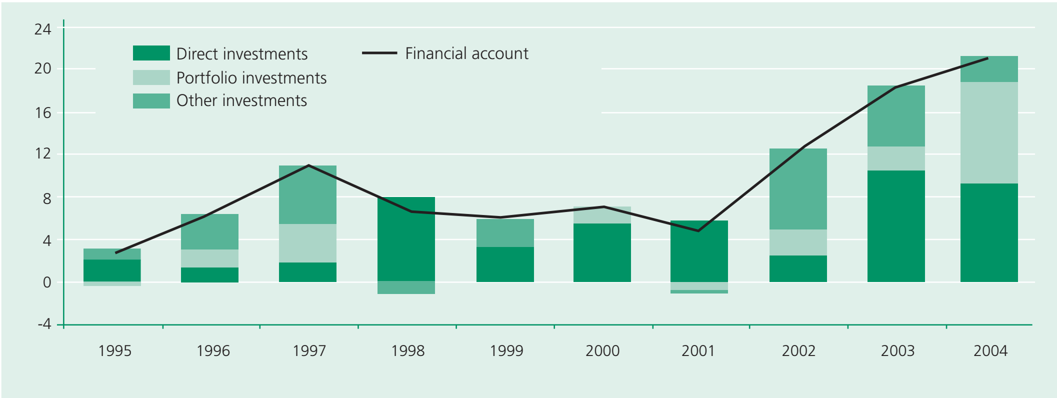
152 The size of Estonian transit cluster is estimated at 10% of the country's GDP, which is a result of the increases during recent years. At the same time, no rapid growth in this share is to be expected. See *Competitiveness of the Estonian Transit Corridor*, Center for Strategic Initiatives, Tallinn, 2003/2004.

Successful socio-economic development requires the production of "star products and services" or at least some operation with "question marks" that have high growth potential; "cash cows" still allow for some profits to be earned, but competition is rapidly tightening in this segment. Most of Estonian produce, however, belongs to the "cash cow" category, while achievements in new promising areas are rather modest. (See also Ch 1.3.)

Even though the services side of Estonia's balance of payments has shown an annually increasing surplus, it is not sufficient to cover both trade balance deficit and also the recently more and more escalating income deficit. In 2004, income deficit amounted to 8.9 billion EEK or 6.3% of GDP.[153]

Whereas in earlier years current account deficit was mostly balanced out by the inflow of foreign direct investments, then, even with the record amount of direct investments received in 2003 and 2004, which the authors consider an exception, it is still the short-term and portfolio investments that have demonstrated the fastest growth in recent years.[154] (Figure 25)

Figure 25. **Changes in the structure of foreign investment capital flows, billion EEK.**



Source: *Eesti maksebilansi aastaraamat 2004* [Estonia's Balance of Payments Yearbook 2004], Eesti Pank, Tallinn 2005.

On the whole, Estonia's gross external debt, excluding foreign direct investments, amounted to 80% of GDP in 2004 and more than 80% in 2004. (Figure 26)

Loan stock to private individuals has increased lately by an almost identical volume with Estonia's gross external debt, exceeding the 29 billion EEK limit by the end of 2004. At the same time, loan portfolio of Estonian commercial banks totalled at more than 90 billion EEK.[155] These results leave Estonia in the worst position among new EU member states, old member states as well as the rest of developed countries – in this group there are only two countries in the world that exceed Estonia (Iceland and New Zealand) – and this is certainly a potential source of concern.[156]

[153] *Estonian balance of payments*, Eesti Pank, http://www.eestipank.info, November 2004.

[154] In contrast to the earlier predictions total inflow of foreign direct investments into Estonia, Latvia, Lithuania, Poland, Czech Republic, Slovakia, Slovenia and Hungary decreased from 23 billion USD in 2002 to 22 billion USD in 2003. Source: *World Investment Report 2004*, UNCTAD, New York and Geneva, 2004, 72, www.unctad.org; see also *Economic Survey of Europe,* 2004 issue 1, New York, United Nations Publications, 2004, 76 ja 83-89.

[155] *Loans granted to customers by groups of customers*, Eesti Pank, http://www.eestipank.info, January 2005.

[156] *IMF Country Report No 04/357*, IMF, http://www.imf.org/external/pubs/ft/scr/2004/cr04357.pdf.

Figure 26. **Estonia's external debt.**

Source: Eesti Pank, http://www.eestipank.info, March 2006; calculations by authors.

3.2. Productivity growth and economic development

Upsetting the external balance of an economy in a fixed exchange rate system is generally expected to automatically cause a slowdown in the inflow of financial resources, which will lead to a decrease in investments and domestic consumption. This, in turn, is expected to reduce the current account deficit. Yet, such type of reduction in the size of economy results in a decline of employment and higher social costs without facilitating any increase in the country's standard of living.[157]

Main factors to determine and facilitate an increase in the standard of living are employment and the value added per inhabitant. The more added value gets created in the country, i.e. the higher the productivity of the economy, the higher is the purchasing power of that country.[158] According to Eurostat, Estonia's GDP per capita in Purchasing Power Standards (PPS) was 49% of the EU average in 2003.[159] Then again, in 2002 Estonia's labour productivity per person employed was 4-5 times and hourly wages 6-7 times lower than the average of the EU15. (Table 8) Nonetheless, in more recent years, the pace of pay increase has surpassed the growth of productivity in Estonia.[160]

[157] While analysing the sources of the 1997 Asian economic crisis Joseph Stiglitz, winner of the Nobel Prize in economics, discovered that automatic stablisers might not always work on financial markets. Outflow of „hot money" and inability to refinance external debt (irregardless of whether it is a public or private sector debt) can easily lead to an economic crisis. This is why it is important for the developing countries that provide foreign-currency loans to raise their liquid foreign currency reserves, and implement the regulatory barriers outlined in the IMF Statutes against the devastating outflow of „hot money", if needed. See, for instance Joseph E. Stiglitz, „Capital Market Liberalisation, Economic Growth, and Instability", *World Development*, 28, 6, 2000, 1075-1086; Ilene Grabel, „International Private Capital Flows and Developing Countries", in Ha-Joon Chang (ed), *Rethinking Development Economics*, UK: Anthem Press, 2003, 325-345.

[158] Relationships between the domestic and international equilibrium of an economy as well as their meaning in economic policy development are very well described by the internationally best known Estonian economist Ragnar Nurkse, who not many people actually know of in Estonia. See Ragnar Nurkse, „Domestic and International Equilibrium", in Seymour Edwin Harris (ed), *The New Economics: Keynes' Influence on Theory and Public Policy*, New York: A. A. Knopf 1947, 264-292.

[159] *GDP per capita in Purchasing Power Standards (PPS)*, Eurostat, 12 February 2005, http://europa.eu.int/comm/eurostat/.

[160] Robert Burgess, Stefania Fabrizio and Yuan Xiao, *Competitiveness in the Baltics in the Run-Up to EU Accession*, *IMF Country Report No 3/114*, April 2003, 5, http://www.imf.org/external/pubs/ft/scr/2003/cr03114.pdf; see also Marek Tiits, Rainer Kattel, Tarmo Kalvet, Rein Kaarli, *The Estonian Economy.Competitiveness and Future Outlooks*, Tallinn: Research and Development Council, 2003, 17.

Table 8. **Hourly wage and labour productivity in Europe.**[161]

	Hourly labour costs[162] euros, 2000	Labour productivity per person employed**, 000 euros, 2002	Weekly working hours (full-time work), 2002
Czech Republic	3.90	16.9	42.4
Estonia	3.03	12.0	40.8
Cyprus	10.74	n/a	40.9
Latvia	2.42	12.0	43.6
Lithuania	2.71	10.7	39.4
Hungary	3.83	17.0	41.2
Poland	4.48	16.9	42.7
Slovenia	8.98	25.4	41.3
Slovakia	3.06	13.3	42.1
EU25	**19.09**	**51.9**	**39.2**
EU15	**22.21**	**57.6**	**38.7**

Source: *The New EU of 25 Compared to EU15, News Release 36/2004*, Eurostat, 11 April 2004, http://europa.eu.int/comm/eurostat/.

The main source of economic gap between Germany and Estonia, just like all other Central and Eastern European countries, resides in the low level of productivity in the manufacturing industry of this region. In 2000, 28% of Estonia's productivity gap resulted from the low productivity levels of manufacturing industry.[163] Yet despite the lag manufacturing industry has still been the major source of productivity growth in a number of new member states of the European Union over the period of 1993-2000. While manufacturing industry occupied the first position everywhere, the other more important sources of productivity growth in Estonia were transport, storage and communication, and modernisation of health and social work. During the period mentioned above more than 40% of the productivity growth of the Estonian economy was derived from these three sectors.[164] (Table 9)

This simple calculation demonstrates, among other things, that transport sector, which has traditionally enjoyed a more prominent status in Estonian economic policy than manufacturing sector, has actually contributed significantly less to the productivity growth of the Estonian economy than manufacturing industry.

[161] These indicators cover industry and services.

[162] Hourly labour costs mean annual labour costs divided by the number of hours worked. The EU25 indicator excludes here Belgium and Malta.

[163] Johannes Stephan, *Evolving Structural Patterns in the Enlarging European Division of Labour: Sectoral and Branch Specialisation and the Potentials for Closing the Productivity Gap*, Halle: Institut für Wirtschaftsforschung Halle – IWH, 5/2003, 19, http://www.iwh-halle.de/projects/productivity-gap/publications/Report_WP1.pdf.

[164] Statistically, productivity growth rates are an aggregate effect of productivity changes in individual sectors (manufacturing, services, agriculture etc) and employment shifts between sectors. Even though Estonian economy has gone through major structural changes over the past ten years, productivity in various sectors has remained fairly similar, and thus only 16% of the productivity growth of the Estonian economy in the periof of 1991-2000 has actually been derived from the structural changes. *Ibid*, 27-29.

Table 9. **Ranking of most influential branches as a source of manufacturing productivity growth, between 1993/1994 and 1999/2000.**[165]

Estonia

D	Manufacturing	21.0%
I	Transport, storage and communication	11.3%
N	Health and social work	9.7%
	Total sum of the above 3 sectors	**42.0%**

Poland

D	Manufacturing	20.3%
A	Agriculture, hunting and forestry	15.4%
G	Wholesale and resale trade	14.0%
	Total sum of the above 3 sectors	**49.7%**

Czech Republic

D	Manufacturing	30.6%
G	Wholesale and resale trade	12.4%
F	Construction	7.8%
	Total sum of the above 3 sectors	**50.8%**

Slovakia

D	Manufacturing	27.7%
A+B	Agriculture, forestry and fishing	9.6%
I	Transport, storage and communication	9.4%
	Total sum of the above 3 sectors	**46.7%**

Hungary

D	Manufacturing	28.8%
G	Wholesale and resale trade	12.4%
I	Transport, storage, communication	9.8%
	Total sum of the above 3 sectors	**51.0%**

Slovenia

D	Manufacturing	34.4%
G	Wholesale and resale trade	12.6%
F	Construction	7.2%
	Total sum of the above 3 sectors	**54.2%**

Source: Johannes Stephan, *Evolving Structural Patterns in the Enlarging European Division of Labour: Sectoral and Branch Specialisation and the Potentials for Closing the Productivity Gap*, Halle: Institut für Wirtschaftsforschung Halle – IWH, 5/2003, 31, http://www.iwh-halle.de/projects/productivity-gap/publications/Report_WP1.pdf.

Economic growth, or productivity growth of the economy, do not, by themselves, necessarily ensure the ability of companies to successfully maintain their position on the increasingly competitive global market. A more detailed analysis shows also that in both the Slovak Republic and Estonia above-average annual rates of national productivity in comparison to the EU15 during the period of 1993/1994-1999/2000 resulted largely from falling employment and structural shifts in employment at the sectoral level. Therefore, there are reasons to believe that the technological content of productivity growth has been lower in the development of these countries than predicted by productivity growth rates. At the same time, technological development has been the main source of manufacturing productivity growth in the other countries presented in Table 9.[166]

Then again, the above is a clear signal to those who develop economic policy in Estonia that there is, indeed, a need for additional initiatives that aim to increase the competitiveness of our companies. Since trade balance deficit accounts for the largest share of Estonia's current account deficit – in comparison with the "old Europe" Estonia's manufacturing productivity ranks one of the lowest among the six countries studied by Stephan *et al*, yet manufacturing productivity growth still yields potentially the highest contribution to the development of the economy – then further analyses (and reflections of a possible future Estonian development strategy) have best to focus on the development of manufacturing as well as transport, storage and communication sectors.[167]

165 Contribution to the productivity growth of the economy is calculated as a fraction of the sum of all weighted sectoral productivity growth rates, weighted by employment shares.

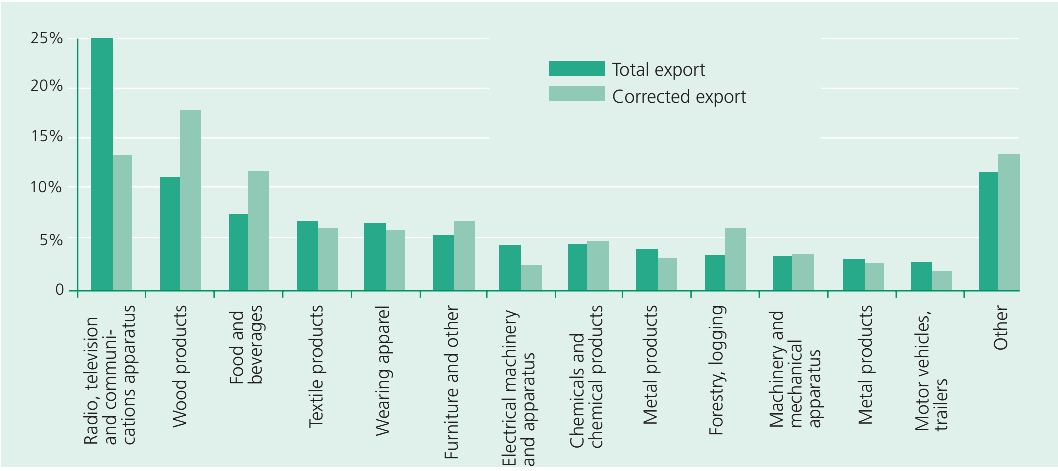
166 *Ibid*, 33. In Estonia high intensity of structural change in manufacturing industry has had a significant impact on productivity growth with the structure of its manufacturing industry resembling that of Germany by the turn of the century. Namely, more than one fifth of the manufacturing productivity growth can be traced back to employment shifts at the expense of branches which achieved lower levels of efficiency in the use of resources. Had it not been for this particular reallocation of employment between branches of manufacturing, Estonia's productivity growth in this sector would have turned out to be much lower at an average 4.8% per annum for the period of 1993-2000. See Johannes Stephan, *Evolving Structural Patterns in the Enlarging European Division of Labour: Sectoral and Branch Specialisation and the Potentials for Closing the Productivity Gap*, Halle: Institut für Wirtschaftsforschung Halle – IWH, 5/2003, 50-51, http://www.iwh-halle.de/projects/productivity-gap/publications/Report_WP1.pdf.

167 *Ibid*, 33.

European Competitiveness Report, published by the European Commission in 2003, repeats again the same conclusion many analysts have arrived at earlier – that the economies of several Central and Eastern European countries (incl. Bulgaria, Latvia, Lithuania, Poland and Romania) reveal external trade and manufacturing specialisation structures that have become 'locked in' the traditionally rather labour-intensive, low-skill sectors. Specialisation structures of Hungary, Czech Republic, Slovakia as well as Estonia, on the other hand, have shown a fairy rapid increase in the share of more technology-driven sectors. Along these lines, it is also observed that specialisations of different countries are largely determined by foreign direct investments plus education and labour supply structures.[168]

High technology sectors like information and telecommunication technologies and electronics do make up a significant share in the specialisation and export structures of Estonia, Hungary and other Central and Eastern European countries. Yet their contribution to the added value of exports still turns out to be considerably smaller than that of several more traditional resource-intensive sectors. (Figure 27) These developments might first appear surprising, but they are really explained by the ever-expanding globalisation and vertical intra-industry trade where price competition has driven less competitive functions of this sector into the cheaper Central and Eastern European countries, whereas control over all activities and profit generation remains in the developed countries.[169]

Figure 27. **Export structure in 2001, adjusted to gross and added value.**



Source: Ülo Kaasik, *Eesti eksporditoodete lisandväärtus* [Added value of Estonian exports], Working Papers of Eesti Pank, 3, 2003, 11.

A more detailed analysis of specialisation patterns within different industries reveals that during the period of 1995-2000 low technology industries of the Baltic countries have shifted towards more medium and high technology functions at the same time as high technology industries are increasingly specialising in low and medium technology segments.[170]

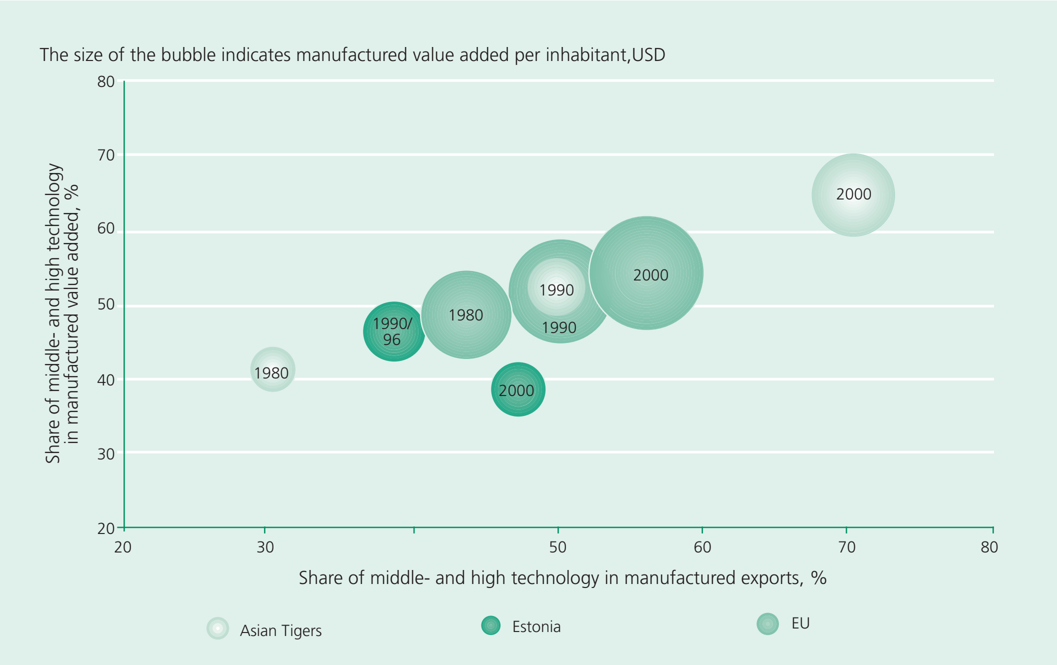
168 *European Competitiveness Report 2003*, European Commission, 2004, 229, http://europa.eu.int/comm/enterprise/enterprise_policy/competitiveness/doc/comprep_2003_en.pdf.

169 In Estonian context, the role of international corporations is evident already in the one example of the the import-export status of *Elcoteq Tallinn LLC* that has emerged as one of the biggest employers in Estonia. It is not the fact whether international statistics views Estonia as a high technology country due to the contribution of *Elcoteq Tallinn LLC* to our export indicators that is important. Rather, it is the understanding that we need to achieve the integration of local companies into international production – i.e. added value creation chain, and continued upward movement on the value chain, that actually matters. See also Dieter Ernst and Linsu Kim, „Global Production Networks, Knowledge Diffusion, and Local Capability Formation", *Research Policy*, 31, 8-9, 2002, 1417-1429; Hubert Gabrisch and Maria Luigia Segnana, *Vertical and Horisontal Patterns of Intra-industry Trade Between EU and Candidate Countries*, Halle, 2003, 32, http://www.iwh-halle.de/projects/productivity-gap/.

170 Uwe Dulleck, Neil Foster, Robert Stehrer and Julia Wörz, *Dimensions of Quality Upgrading in CEECs*, WIIW Working Papers 29, 2004, 11-12, http://www.wiiw.ac.at/pdf/wp29.pdf.

Technology transfer that accompanies foreign direct investments has, on the one hand, had a crucially stimulating role in Estonian development, which is common for the countries in investment-based phase of development. In the 1990s, on the other hand, we also witnessed stagnation in the structure of Estonian industry with specialisation on low technology and resource-intensive activities that do not allow for further income growth today. (Figure 28)

Figure 28. **Development of industry in Estonia, Western Europe and South East Asia, 1980-2000.**[171]



Source: *Industrial Development Report 2004. Industrialization, Environment and the Millennium Development Goals in Sub-Saharan Africa*, UNIDO, UNIDO: Vienna, http://www.unido.org/, 2004; calculations by authors.

Such a situation is a result of both the dissolution of the market of the Soviet Union, and the harsh economic logic according to which it is always the relatively more advanced industry of the comparatively less advantaged country that gets wiped out first in the process of opening up markets.[172]

If Estonia was to survive in the established price competition, it would take as low as possible unit costs of products or as cheap labour as possible, and a rapidly growing volume of production.[173] Estonian medium and low technology enterprises operate today under the conditions of diseconomies of scale, i.e. increasing volume leads to a decrease in the amount of added value per unit. This distinctly points to the inadequacy of the technological solutions they use and to the presence of considerable price competition. On the one hand, it indicates vigorous modernisation, but on the other hand, it also implies intensive concentration and diminishing specialisation in the economy.[174]

171 Figure 28 depicts data from the following countries. EU-15: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden, United Kingdom. Asian tigers: Korea, Malaysia, Singapore, Thailand. Calculations of the average are presented in all cases.

172 Vanek-Reinert effect, Erik S. Reinert, *International Trade and the Economic Mechanisms of Underdevelopment*, Ph D. Thesis, Cornell University, Ann Arbor, Michigan, 1980; Erik S. Reinert (ed), *Globalization, Economic Development and Inequality: An Alternative Perspective,* Cheltenham: Elgar, 2004; see also Erik S. Reinert and Rainer Kattel, *The Qualitative Shift in European Integration: Towards Permanent Wage Pressures and a 'Latin-Americanization' of Europe?*, Tallinn: PRAXIS Working Paper no 17/2004, 2004 http://www.praxis.ee/data/WP_17_20042.pdf.

173 See e.g. Marek Tiits, Rainer Kattel, Tarmo Kalvet, Rein Kaarli, *The Estonian Economy. Competitiveness and Future Outlooks*, Tallinn: Research and Development Council, 2003.

174 Rainer Kattel and Riivo Anton, „The Estonian Genome Project and Economic Development", *TRAMES*, 1/2, 8, 2004.

Backwardness in Estonian manufacturing sector derives mostly from the low productivity levels of food, textiles and wood processing industries. Since Estonian manufacturing sector is almost completely specialised on areas that relate to wood processing, it is reasonable to focus Estonia's economic catch-up with Western Europe, at least in the immediately upcoming years, primarily on increasing the productivity in the wood processing industry (incl. manufacture of furniture and paper) that currently dominates the specialisation structure. (Table 10)

Table 10. **Ranking of most influential branches as a source of manufacturing productivity growth, between 1993/1994 and 1999/2000.**

Estonia		
DN	Furniture and other manufacturing	18.8%
DD	Manufacture of wood and wood products	15.6%
DL	Manufacture of electrical and optical equipment	10.5%
	Sum of the 3 branches	**44.9%**

Poland		
DA	Manufacture of food products, beverages and tobacco	16.6%
DK	Manufacture of other machinery and equipment	9.1%
DI	Manufacture of other non-metallic mineral products	8.3%
	Sum of the 3 branches	**34.0%**

Czech Republic		
DM	Manufacture of transport equipment	15.9%
DK	Manufacture of other machinery and equipment	15.5%
DJ	Manufacture of basic metals and fabricated metal products	13.7%
	Sum of the 3 branches	**45.1%**

Slovakia		
DM	Manufacture of transport equipment	22.8%
DK	Manufacture of other machinery and equipment	14.6%
DL	Manufacture of electrical and optical equipment	12.7%
	Sum of the 3 branches	**50.1%**

Hungary		
DL	Manufacture of electrical and optical equipment	22.6%
DA	Manufacture of food products, beverages and tobacco	14.1%
DM	Manufacture of transport equipment	16.6%
	Sum of the 3 branches	**53.3%**

Slovenia		
DJ	Manufacture of basic metals and fabricated metal products	17.1%
DK	Manufacture of other machinery and equipment	13.1%
DB	Manufacture of textiles and textile products	12.4%
	Sum of the 3 branches	**42.6%**

Source: Johannes Stephan, *Evolving Structural Patterns in the Enlarging European Division of Labour: Sectoral and Branch Specialisation and the Potentials for Closing the Productivity Gap*, Halle: Institut für Wirtschaftsforschung Halle – IWH, 5/2003, 51, http://www.iwh-halle.de/projects/productivity-gap/publications/Report_WP1.pdf.

3.3. *Acquis communautaire* and innovation

Adoption of the *acquis communautaire* of the European Union has been another major factor besides foreign direct investments to influence the socio-economic development in Central and Eastern European countries. Transposition of the European Union regulation has actually had a much greater impact on technological and thereby also socio-economic development of Estonia than the official innovation policy that focuses mostly on the commercialisation of local research accomplishments. This resulted partially from the general political priorities and partially from the youth and crudeness of Estonian innovation policy.[175]

[175] See also Rainer Kattel, "Innovatsioonipoliitika valitsemine: Eesti näide" [Governance in innovation policy: case of Estonia], in Vello Pettai and Eveli Illing (eds), *Valitsemine ja hea valitsemine*. [Governance and Good Governance] Tallinn: PRAXIS Center for Policy Studies, 2004.

Transposition of the *acquis* at a pace suitable for Estonia, and the investments made to comply with its requirements and introduction of common standards clearly cause long term spillovers in the form of growth in productivity and improved competitiveness of the industry. Albeit *acquis* does not influence all industries in quite the same way, all industries are, in the end, still forced to make significant investments into the modernisation or innovation of their products, working environment, production processes as well as waste management and the like in order to meet the terms imposed by the European Union regulation.[176]

Estonian energy sector is a typical example of how the need to comply with the European Union common regulation forces one sector of the economy into radical renewal. More than 90% of all Estonian electricity is produced by Narva power plants, whose level of efficiency in the production of electricity is less than 30%. Pursuant to the European Union environmental protection requirements all of the old energy blocks currently operating in Narva must be closed down no later than in the year 2015. This year the transfer to new technology should be completed in two blocks in Narva, which will cost a total of 3.9 billion EEK. These two blocks, with their total capacity of 430 MW, are able to cover but about a quarter of the total electric power currently needed in Estonia. Hence, in order to satisfy the domestic energy demand and to observe the environmental protection requirements, Estonian energy production system will have to make significant investments either into the renovation of old power plants or into building new ones.[177]

However, the externally imposed need to quickly implement Western standards may also result, in the short run, in a loss of competitiveness in several sectors of industry in Central and Eastern European countries, which can consequently bring about sudden structural changes in the economy and society. Obligation to fully implement common European regulations can cause serious problems for several new member states, and especially for small enterprises (in a situation where no transition period is granted). Food, chemicals, metal and machinery manufacturing as well as energy sector are deemed to be in the worst position.[178]

Situation in North Eastern part of Estonia in particular, where employment in manufacturing is higher than elsewhere, gives grounds for much concern. On the one hand, this region is one of the richest in Estonia in regard to natural resources, and this is where most of the manufacturing is located with mining, chemical and textile industries playing the main role. Then again, the heavy industries in this area were mostly oriented towards the Soviet Union market, and were no more competitive after the collapse of the Union, and are not really so even now. Restructuring the manufacturing industry is therefore one of the major challenges facing North Eastern Estonia. It has already led to a significant loss of jobs and will most likely continue to do so. Estonian wood processing sector and its development prospects, on the other hand, receive a positive assessment.[179]

It follows from the above that the best opportunities Estonian innovation policy has for facilitating economic development derive from the various fields that relate to modernisation of wood processing industry, and from movement towards higher value-added activities in the value chain. Finnish economic development in the 1970-1980s and the policies implemented to catch up with Sweden offer, in this respect, plenty of valuable and inspiring examples.[180]

[176] Community market standards have greatest impact on food and chemical industries where the regulations of the *acquis* apply to as many as 2/3 of all products. Manufacture of machinery, transport and electrical equipment are also significantly affected by the community market regulation. Occupational health and safety regulation concerns mostly wood processing and chemical industries, whereas competition restrictions apply mostly to metal-working industry. Then again, largest investment duties are levied by the European Union environmental protection requirements that influence most of all coal and metals as well as pulp and paper industries. See Peter Havlik, Michael Landesmann, Roman Römisch, Robert Stehrer and Björn Gillsäter, *Competitiveness of Industry in CEE Candidate Countries: Composite Paper*, Vienna: Vienna Institute for International Economic Studies, 2001.

[177] *Estonian National Development Plan for the Implementation of the EU Structural Funds – Single Programming Document 2004-2006*, 2004, 60-65, http://www.struktuurifondid.ee/failid/ESTONIAN_SPD_2004_2006.pdf; *Long Term Public Fuel and Energy Sector Development Plan*, http://www.mkm.ee/index.php?id=9289.

[178] Peter Havlik, Michael Landesmann, Roman Römisch, Robert Stehrer and Björn Gillsäter, *Competitiveness of Industry in CEE Candidate Countries: Composite Paper*, Vienna: Vienna Institute for International Economic Studies, 2001, 120-144.

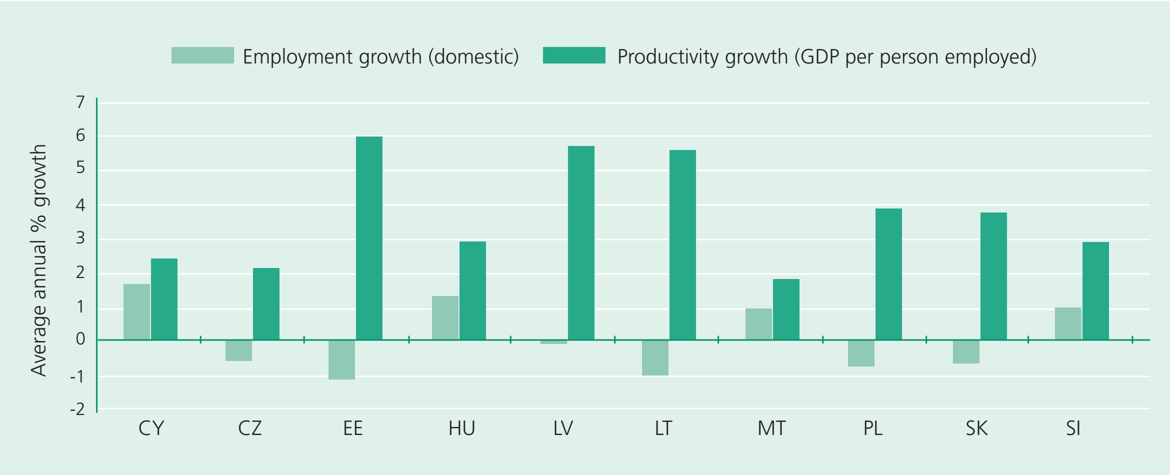
[179] Ibid, 149-150.

[180] See Tarmo Lemola, „Transformation of the Finnish Science and Technology Policy", *Science Studies*, 1/2003, 52-67.

3.4. Human resources, employment and social sustainability[181]

The process of restructuring and modernising Estonian economy and industry has been featured by technological and organisational innovations that established a good basis for productivity growth, but also led to a decline in employment. These developments can be partially attributed to the reduction of the kind of overmanning typical in socialist economies as well as to the introduction of new labour-saving technologies and to the closure of inefficient enterprises. Unfortunately, the more productive enterprises have not been able to create new jobs at the same pace.[182] (Figure 29)

Figure 29. **Average GDP growth in new member states of the European Union during the years 1997-2002.**



Source: *Jobs, jobs, jobs: Creating more employment in Europe, Report of the Employment Task Force chaired by Wim Kok*, Office for Official Publications of the European Communities, 2004, 91.

While total employment has decreased in Estonia by 16% over the past 15 years, employment in manufacturing has dropped as much as 60% and in agriculture even more than 67% during the period of 1989-2003. Whereas in 1989 the share of manufacturing in total employment was 26%, then by 2003 it had fallen to 23%; in agriculture from 18% to below 6%, respectively. Comparatively the highest increase in employment has occurred in wholesale and retail trade whose share in total employment has grown from 7% to 14%. Employment has doubled in financial intermediation. In the light of the lending boom we are also witnessing some expansion in real estate employment. (Table 11)

Notwithstanding the general fall in employment in Estonia, the number of workers in elementary occupations has essentially remained constant, whilst the number of skilled and craft workers has become twice as low (even three times as low in agriculture and fishery). The number of officials has decreased by a third, the number of professionals and associate professionals by a fourth.[183]

[181] For a detailed overview see *Human Development Report 2003*, United Nations Development Programme, UK: Oxford University Press, 2003; *Estonian Human Development Report 2003*, Tallinna Pedagogical University, Tallinn, 2003.

[182] Jaan Masso, Raul Eamets and Kaia Philips, *Creative Destruction and Transition: The Effects of Firm Entry and Exit on Productivity Growth in Estonia*, Institute for the Study of Labor (IZA), Discussion Paper 1243, 2004.

[183] *Employed persons aged 15-69 by sex and major groups of occupation (1989-2003)*, Statistical Office of Estonia, November 2004.

Table 11. **Employment: Employed persons aged 15-69 by economic activity (thousands).**

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Agriculture, hunting and forestry	150.8	140.2	132.2	117.5	96.2	82.8	58.7	55.3	49.7	48.6	43.6	38	36.8	38	33.9	30.8
Fishing	26.5	24.3	23.1	20.2	15.6	12.8	5.8	4.9	6.8	4.8	3.1	2.9	2.7	1.9	2.3	3.6
Mining and quarrying	12.3	12.3	12.1	12.5	11.4	11.1	9.2	8.8	7.1	7.5	7.9	7.2	5.8	5.7	5.6	7.9
Manufacturing	214.9	212.1	202.3	183.1	151.1	140.5	157.7	148.4	136	131.3	122.4	128.9	133.5	127.3	133.5	139.6
Electricity, gas and water supply	18.6	19	18.7	18.3	18.3	19.2	15.4	15.7	16.6	17.2	16.4	14.7	11.4	10.5	10.2	12.0
Construction	64.9	66.1	65.7	60.2	51.6	48.6	34.5	35.5	44.8	44.1	38.9	39.7	39.3	38.9	42.9	46.8
Wholesale and retail trade	61.6	63.2	65.6	71.9	80	85.9	80.1	82.5	86	85.4	81.5	79	83.4	85.7	80.1	79.7
Hotels and restaurants	18.8	18.2	19.1	18	17	18.2	17.2	17	14	13.7	13	19.9	17.3	17.9	17.3	16.2
Trade, storage and communication	65.6	68.3	68.2	62.3	59.1	57.4	63.7	61.9	56.3	54.9	59	56.7	53.6	53.7	56	51.4
Financial intermediation	3.9	4.2	4.8	5.8	6.5	7.7	6.9	6.3	7	8.1	8.6	7.7	7.1	7.9	7.6	7.9
Real estate, renting and business activities	33.6	34	31.8	29	28.3	30	31.2	31	33.5	36.7	36.5	39.2	36.9	43.3	42.8	37.6
Public administration and defence	32.8	32	31.5	32.4	34.5	35.3	34.5	33.7	32.3	34.7	34.6	33.9	34.2	33.1	34.3	36.7
Education	51	48.7	47.6	48.3	48.7	46.9	53.8	54.1	55.6	53.2	49.8	44.2	50.5	54.8	55.7	53.0
Health and social work	50.5	49.5	50.4	48.2	46.9	46.1	35.7	35	35.1	33.4	30.8	28.1	30.4	31	35.7	37.1
Other economic activities	32	33.6	33.5	33.7	33.7	32.8	29	29.2	32.1	28.8	29.3	28.2	29.4	29.6	30.2	28.3
Economic activities total	**837.9**	**825.8**	**806.6**	**761.4**	**698.9**	**675.4**	**633.4**	**619.3**	**613**	**602.5**	**575.3**	**568.3**	**572.2**	**579.3**	**588.1**	588.6
Employment rate (%)	**76.4**	**75.0**	**73.2**	**69.5**	**65.5**	**64.6**	**61.7**	**61.2**	**61.3**	**60.6**	**58.2**	**57.6**	**58.1**	**58.8**	**59.7**	**59.7**

Source: Statistical Office of Estonia, March 2006.

In recent years, employment has declined in the medium and high technology branches of Estonian manufacturing industry remaining at 3.4% in 2003 (4.9% in 2001), which is only about half of the EU15 and EU25 average indicator. The same applies to employment in medium and high technology branches of services industry[184] – Estonia's employment in the respective sector (2.3% in 2003) constitutes 66% of the equivalent indicator for EU15 and 73% of the EU25.[185]

Since structural changes in the economy have led to specialisation in less knowledge and skills intensive activities and a large part of industry is experiencing diseconomies of scale (see Ch. 3.2), it is not surprising that in Estonia a 1% increase in labour costs results in a 0.26% decrease in employment.[186] This generates strong pressure to reduce taxes and differentiate (read: reduce) minimum wage levels, because otherwise current cost-based competitive advantages do not render companies competitive anymore. Even if cost-cutting would, in the short run, help the less successful companies save jobs, it really only delays the process of finding proper solutions to the structural problems facing Estonian economy.

[184] It is important to remember that knowledge-intensive services are characterised by a certain employment minimum regardless of the size of the country they are located in. Hence, in a smaller country this means a relatively larger portion of total employment. Secondly, exportable services constitute only a rather small part in the standard list of knowledge-intensive services. This is why, after all, they only make a limited contribution to fostering economic development and competitiness, as defined by the authors of this book.

[185] *European Innovation Scoreboard 2004. Comparative Analysis of Innovation Perfomance*, European Commission, 2004, http://trendchart.cordis.lu/scoreboards/scoreboard2004/pdf/eis_2004.pdf; *European Innovation Scoreboard 2004. Annex 2. Country Pages EU25 + Candidate countries*, European Commission, 2004, http://trendchart.cordis.lu/scoreboards/scoreboard2004/pdf/eis_2004_annex2.pdf.

[186] Janno Järve, *Tööjõukulude mõju tööjõu nõudlusele Eesti tööstusettevõtetes* [Impact of labour costs on labour demand in Estonian manufacturing enterprises], Policy Analysis 1/2002, Tallinn: PRAXIS Center for Policy Studies; Marit Hinnosaar, Tairi Rõõm, *The Impact of Minimum Wage on the Labor Market in Estonia: an Empirical Analysis*, Working papers of Eesti Pank, 8, 2003.

Despite the high (and often long term) unemployment in Estonia, entrepreneurs are unable to find suitably qualified labour. An even more important problem is actually the modest number of well-qualified science and engineering graduates.[187] (See also Table 12)

Table 12. **Share of science and engineering[188] graduates among the 20-29 years age class, 1993-2002.**

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Ireland	19.10	21.00	21.40	21.90	21.80	22.40		23.20	21.70	20.50
Finland	13.20	13.00	13.00	13.10	15.80	15.90	17.80	16.00	17.20	
Lithuania					7.30	9.30	11.70	13.50	14.80	14.60
Sweden	6.20	6.30	7.30	7.40	7.80	7.90	9.70	11.60	12.40	13.30
Japan			12.70	12.50		12.36	12.76	12.97	13.04	
EL-15					**10.30**	**10.70**	**11.12**	**11.43**	**12.38**	**12.47**
Bulgaria					6.00	5.50	6.50	6.60	7.90	11.70
EL-25					**9.28**	**9.67**	**10.12**	**10.45**	**11.30**	**11.49**
US	10.30	10.90	11.20	11.50		9.60	9.70	10.20		
Slovenia					6.30	8.00	8.40	8.90	8.20	9.50
Latvia					6.90	5.90	6.30	7.50	7.60	8.10
Estonia					**4.20**			**7.00**	**7.30**	**6.60**
Netherlands	5.50	5.40	5.60	6.60		6.00	5.80	5.80	6.10	6.60
Hungary					5.00	5.00	5.10	4.50	3.70	4.80

Source: *European Innovation Scoreboard 2004, Comparative Analysis of Innovation Perfomance*, European Commission, 2004; *European Innovation Scoreboard 2004. Annex 2. Country Pages EU25 + Candidate countries*, European Commission, 2004, http://trendchart.cordis.lu/scoreboards/scoreboard2004/.

People who used to be economically active earlier, but lost their jobs and are in need of retraining, find that their existing skills are only good enough for minimum wage jobs or no good for any work at all. Yet it is not only the productivity, but also the size of labour force that are critical to maintaining or increasing the general standard of living.[189] Today's high unemployment levels among the 15-24 year age group, which amount to 17% for men and even 26% for women, is a cause for particular concern in this context.[190] (Figure 30)

[187] About information and communication technology sector see Rainer Kattel and Tarmo Kalvet, *Teadmistepõhine majandus ning infotehnoloogiaalane haridus: hetkeolukord ning väljakutsed haridussüsteemile aastani 2008* [Knowledge-Based Economy and Information Technology Education: Existing Conditions and Challenges Facing the Educational System up to the Year 2008], PRAXIS Center for Policy Studies, 2005.

[188] Science and engineering (S&E) graduates are defined as all post-secondary education graduates (educational groups 5a and above) in life sciences (ISC42), physical sciences (ISC44), mathematics and statistics (ISC46), computing (ISC48), engineering and engineering trades (ISC52), manufacturing and processing (ISC54) and architecture and building (ISC58).

[189] Although it was, indeed, also implemented in the Soviet Union, full employment policy as one of the core elements of the European Union Lisbon strategy is not at all tied to any socialist approach. After the „great depression" of the 1930s most developed industrialised countries shared the view that securing full employment is one of government's main tasks. Demand and productivity growth were supposed to be key sources for covering sizeable labour costs. Likewise, 19th century policies of Napoleon III attributed much importance to securing employment for the poor during economic recession in order to prevent hunger and uprising. Thus, even if technology-driven reduction in the number of jobs is a part of the toll that reorientation to high technology takes, it is still vital to adopt preventive measures to try and sustain employment levels. This is the very reason why a transition to high technology sectors and extensive structural changes must, nonetheless, begin with the modernisation of the existing labour-intensive traditional industry where available resources facilitate and volumes allow for real expansion.

[190] See also *Labour Market and Social Policies in the Baltic Countries*, OECD, 2003, http://213.253.134.29/oecd/pdfs/browseit/1403021E.PDF.

Figure 30. **Unemployment levels in Estonia 1993-2004.**

Source: *Statistics database*, Statistical Office of Estonia, April 2004.

Albeit Estonia's 60% employment rate in 2004 compares well to the European Union average, it gets nowhere close to the 70% level in the United States. Shorter working time, lower employment rates and productivity are also among the main reasons why Europe is economically lagging behind the United States. Even though it is the very goal of the Lisbon strategy to achieve the 70% employment level in Europe by 2010, the actual realisation of this objective does not look very feasible. This does not mean, however, that achieving these goals would somehow have become less critical to the European competitiveness *vis-à-vis* USA, China and South East Asia.[191]

While EU15 countries are investing an average 1% of their GDP into active labour market policies, new member states contribute only 0.2% of GDP. Although Estonia's active labour market policies have proven effective, and every kroon invested into employment training has brought 3 kroons in return for the society, spending on active labour market policies in Estonia still accounted for a mere 0.08% of GDP in 2002.[192]

Rise in the number of inactive people is, again, inevitably linked to growing wealth stratification. Hence, most of the Central and Eastern European transition countries have been experiencing a dramatic increase in financial inequality over the past 15 years.[193] Both the insecurity of the transition period, and the fact that 30% of the families with two children and 45% of the families with three children live below the poverty line in Estonia (at risk of poverty even as many as 60% of the latter),[194] in turn, clearly affect general demographic trends. An overview of income distribution in various new member states of the European Union demonstrates that the distribution is most uneven precisely in Estonia. (Figure 31)

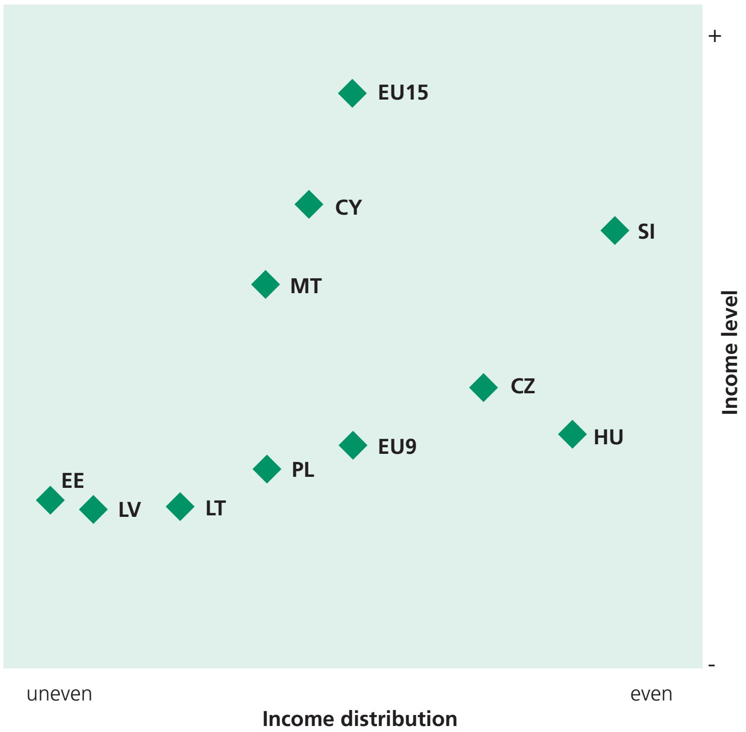
[191] Achieving the 70% employment goal in Estonia by 2010 would require additional 60-70 thousand people to be employed over the following five years. See also *Facing the Challenge: The Lisbon Strategy for Growth and Employment, Report from the High Level Group Chaired by Wim Kok*, European Commission, November 2004, 11-12, http://europa.eu.int/comm/lisbon_strategy/pdf/2004-1866-EN-complet.pdf; *Employment in Europe 2004: Recent Trends and Prospects*, European Commission, 2004; *The EU Economy: 2004 Review*, European Commission, Brussels, 2004, 4.

[192] Reelika Leetmaa, Andres Võrk, Raul Eamets, Kaja Sõstra, *Aktiivse tööpoliitika tulemuslikkuse analüüs Eestis* [Analysis of the effectiveness of proactive employment policy in Estonia], Tallinn: PRAXIS Center for Policy Studies, 2003; *Key Structural Challenges in the Acceding Countries: The Integration of the Acceding Countries into the Community's Economic Policy Co-ordination Processes*, European Economy, Occasional papers no. 4, European Commission, July 2003.

[193] *Transition: First Ten Years*, World Bank, Washington D.C. 2002, 9.

[194] *Leibkonna sissetulekute ja kulutuste uuring* [Survey of household income and expenditure], Statistical Office of Estonia, 2000.

Figure 31. **Income level and distribution in various new member states of the European Union.**



Source: Tobias Hüsing, *The Impact of ICT on Social Cohesion: Beyond the Digital Divide*, Paper presented at the 14th Economic Forum, September 9-11, 2004, Krynica Zdrój, Poland, 2004, 8, http://fiste.jrc.es/download/impact%20of%20ict%20on%20social%20cohesion%20-%20huesing%20-%20final%20draft%20.pdf.

While in Europe employment is already rapidly declining as a result of aging population, in Estonia labour supply should remain pretty much at the same level without migration until 2015, then starting to fall rapidly due to low birth rates experienced throughout the past ten years.

The most tangible indication of these upcoming trends is the fact that the number of 16-18 year olds is going to start its plunge in Estonia already in 2007, and by 2015 its level will be half of that in 2003.[195] This, in turn, means that the need for student places in higher and vocational education system that follows the basic and secondary education will halve. Yet in order to adhere to the *Lisbon strategy* we should be increasing the number of the 24-65 year olds participating in further training by 2.4 times by the year 2010.[196]

In addition, by the year 2020 the age group of 15-24 years will comprise half as many people as in 2000 due to the impact of low birth rates in Estonia. (Figure 32) Whereas today there are four working-age people per one retired person, according to the estimates of the UN this number will drop to three by the year 2025 and to less than two by the year 2050.[197] This rapid aging of population that is taking over the whole Europe will inevitably lead to an intense competition for immigrants: most particularly among the highly qualified specialists.[198]

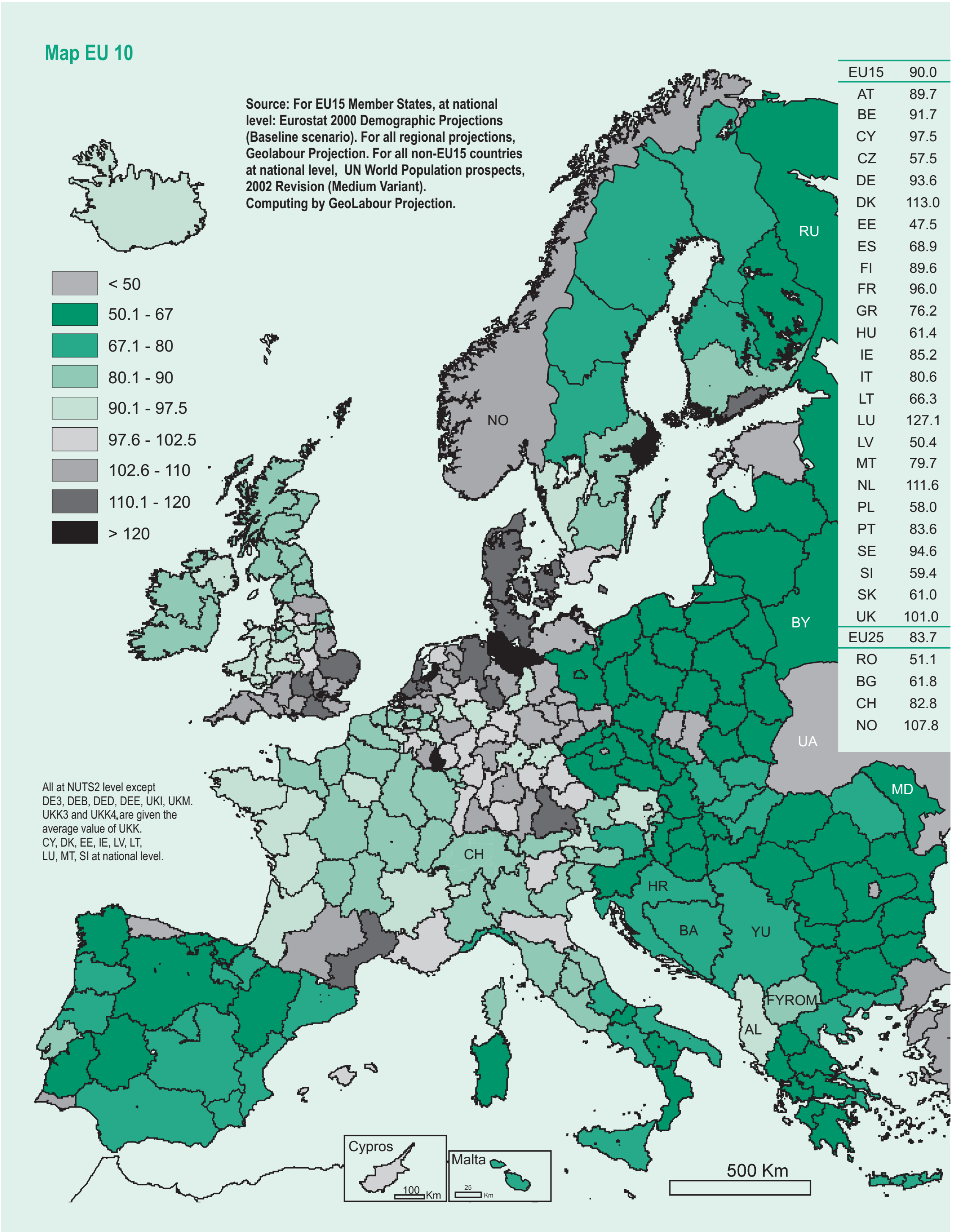
[195] Reelika Leetmaa, *Eesti tööturg ja Lissaboni strateegia eesmärgid* [Estonian labour market and the objectives of Lisbon strategy], presentation, Tartu, 5th Novemeber 2004.

[196] Tiina Annus, Jussi S. Jauhiainen, Katrin Jõgi, Jaak Kliimask, Liis Kraut, Mihkel Laan, Rivo Noorkõiv, Garri Raagmaa, Aloysius Ferdinand Maria (Loek) Nieuwenhuis, *Kutseõppeasutuste võrgu korraldamine lähtuvalt regionaalsest spetsialiseerumisest* [Organisation of vocational school network in accordance with regional specialisation], Tallinn: PRAXIS Center for Policy Studies, 2003, http://www.praxis.ee/data/Koolivqrk0.pdf.

[197] *World Population Prospects: The 2002 Revision Population Database*, United Nations, http://esa.un.org/unpp, December 2003.

[198] See e.g. *Best Before 01012015, Future Makers – Finland 2015*, Sitra, 2003, http://194.100.30.11/suomi2015/suomi2015_7/english/Best_%20before_01012015.pdf.

Figure 32. **Number of people in the age group of 15-24 years in 2020 (2000 = 100%).**



EU15	90.0
AT	89.7
BE	91.7
CY	97.5
CZ	57.5
DE	93.6
DK	113.0
EE	47.5
ES	68.9
FI	89.6
FR	96.0
GR	76.2
HU	61.4
IE	85.2
IT	80.6
LT	66.3
LU	127.1
LV	50.4
MT	79.7
NL	111.6
PL	58.0
PT	83.6
SE	94.6
SI	59.4
SK	61.0
UK	101.0
EU25	83.7
RO	51.1
BG	61.8
CH	82.8
NO	107.8

Source: Géry Coomans, *Atlas of Prospective Labour Supply*, Geolabour, Dublin 2004, http://www.geolabour.com.

Estonia is also facing some major challenges in health care. Besides the needs, for instance, to reform Estonian hospital network and secure the development of health care system, Estonia is also approaching critical conditions in regard to HIV/AIDS. It is estimated that in about ten years time at the latest every third premature death in Estonia will be caused by HIV/AIDS.[199] Along the same lines, the US Central Intelligence Agency (CIA) has warned that the epidemic spread of HIV/AIDS in Russia is likely to aggravate its social, economic, health care and military problems. United Nations Development Program estimates that the HIV epidemic in Russia will cause a 10-12% decrease in GDP.[200] Estonia's situation is even more complicated. In the region of the former Soviet Union the virus is spreading fastest precisely in Estonia; the number of HIV-infected people per inhabitant is second highest in Russia, followed by Ukraine, Latvia and Byelorussia. Plus the level of AIDS illness is about twice as high in the population of Estonia as it is in Byelorussia.[201]

According to OECD assessment, high unemployment levels, modest incomes, and a much more uneven income distribution than in many European countries do not really leave Estonian government many choices. Estonian labour market policy must adopt the establishment of such an institutional framework that facilitates innovation and new job creation as its main goal.[202]

199 Presentation by former Minister of Social Affairs Marko Pomerants at a cabinet meeting, 18th November, 2004.

200 *The Next Wave of HIV/AIDS: Nigeria, Ethiopia, Russia, India, and China*, Central Intelligence Agency, 2002, 28, http://www.cia.gov/nic/PDF_GIF_otherprod/HIVAIDS/ICA_HIVAIDS20092302.pdf.

201 See also Olusoji Adeyi, Enis Baris, Sarbani Chakraborty, Thomas Novotny, Ross Pavis*, Averting AIDS Crises in Eastern Europe and Central Asia - A Regional Support Strategy*, World Bank, September 2003; Ruta Kruuda, Maris Jesse, Kadi Viik, *HIV/AIDSi ennetustegevuse hindamine Eestis 2004* [Evaluation of HIV/AIDS prevention program in Estonia 2004], PRAXIS Working Paper 16/2004, http://www.praxis.ee/data/toimetised_16_2004_templatis0.pdf.

202 *Labour Market and Social Policies in the Baltic Countries*, OECD, Paris 2003.

4. Estonia's competitive position in Europe

4.1. About the economic opportunities of our children

While campaigning in 1928 Herbert Hoover still believed in the America of the "Progressive Era" and was not shy about spelling it out: "We in America today are nearer to the final triumph over poverty than ever before in the history of any land." This message appealed to voters. Hoover, who became the US president a year later, was a champion of individualism, market efficiency, international gold standard and balanced budget policy. Focusing on increasing government efficiency, cutting taxes, public-private cooperation instead of regulation and the rapidly developing American industrial economy will take care of the rest were prevalent slogans of the era.[203] Even the *Ladies' Home Journal* declared: in fact, everyone should be rich, because you only have to invest a tiny bit every week to make a fortune in 20 yeas time.

In October 1929 the US stock market crashed. The following economic collapse and the Great Depression that devastated the whole Western world put Hoover's previously solid-sounding faith in free enterprise into a naïve and even tragic light. John Maynard Keynes, who brought the world out of the Great Depression in the 1930s, did not consider planned economy feasible, but he did devote a whole essay on describing the development prospects of the capitalist economy for the coming hundred years (*sic!*).[204] This experience shows that viewing government and enterprise as adversaries is indeed destructive, and in no way supports the progress of society.

It is in the nature of human beings to expect that in their quest for stability and well-being, future will be a progressively favourable continuation of current positive developments. Alas, the history is full of examples of both government and market failures. No one is safe from ill fortune or incompetence, especially in a small open economy, which is largely at the mercy of global trends. Consequently, today's increases in oil prices, growth in political tensions and ongoing warfare generate multiple trends in the global economy that render the future rather insecure. A reasonable balance between government regulation and free market logic is, thus, essentially the safest path towards future.

Whereas in 1997 the inability to refinance their loans and the exhaustion of foreign reserves caused by the outflow of "hot money" led first Thailand and then a number of other South East Asian countries to abandon dollar-pegged exchange rates and to an acute economic crisis, then by now the situation appears reversed with some similarities evident in the economic difficulties the US was going through at the end of the 1980s. USA is experiencing major trade deficit and rapid growth in external debt,[205] which have caused the dollar exchange rate to decline to the level of early 1990s. In recent years it is the rapidly growing Asian countries that have become the main creditors to the US government. (Figure 33) The more dollar exchange rate declines, the less attractive American bonds become as potential investment targets for Asian central banks. Since yuan is pegged to the dollar, this decline in dollar exchange rate also cannot alleviate the American trade deficit, which is largely generated by Chinese imports. On the other hand, it would be as hard for the Asian countries to de-peg their currencies, because, for instance, a potential 20% rise of yuan against dollar would mean for China alone a 100 billion dollar hole (ca 8% of China's GDP) in foreign reserves, plus a significant setback in exports to the US.[206]

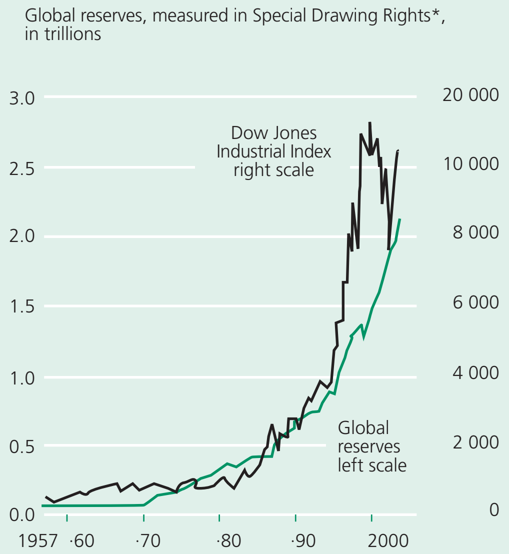
[203] Ronald Edsforth, *The New Deal: America's Response to the Great Depression (Problems in the American History)*, Blackwell Publishers, 2000, 11-13.

[204] John Maynard Keynes, "Economic Possibilities for Our Grandchildren", published as John Maynard Keynes, *Essays in Persuasion*, New York: W.W.Norton & Co., 1963 [1932], 358-373.

[205] See also W Joseph Stroupe, "Crisis towers over the dollar", *Asia Times*, 25.11.2004, http://www.atimes.com/atimes/Global_Economy/FK25Dj03.html; Brett Arends, "On State Street", *Boston Herald*, 23.11.2004, http://business.bostonherald.com/businessNews/view.bg?articleid=55356.

[206] See e.g. Robin Shepherd, "New Europe's economic challenges", *United International Press*, 10.12. 2004; Brian Bremner and Pete Engardio, "The Makings of a Meltdown", *The Economist*, 13.12. 2004; Michael R. Sesit "Currency Reserves, and Concerns, Build Up", *Wall Street Journal Europe*, 11.02. 2004; Richard Duncan, *The Dollar Crisis: Causes, Consequences, Cures*, John Wiley & Sons, 2003.

Figure 33. **Growing financial bubble?**



* An artificial currency unit of the IMF, based upon several national currencies

The largest Asian reserve holders, in billions of dollars.

	2002	2003
China	286.4	403.3*
Hong Kong	111.9	118.4
India	70.4	100.6
Indonesia	32.0	36.3
South-Korea	121.4	155.4
Malaysia	34.6	44.9
Philippines	16.1	16.7
Singapore	82.3	96.3
Taiwan	161.7	206.6
Thailand	38.9	42.1
Japan	469.7	673.5

* Excludes $45 billion China transferred to two banks in late December

Source: Michael R. Sesit, „Liquidity pool Amassed By Asian Central Banks Sparks Inflation Worries", *Wall Street Journal Europe*, 02.02. 2004.

While Asian Tigers and China are enjoying the fruits of their consistent economic policies of the past 50 years, Russia's exports to the European Union – one of its main markets of destination – are dominated by growing specialisation on natural resources and/or cheap labour intensive economic activities. Recent increase in oil prices has, indeed, improved Russia's economic situation, but this alone is still not enough to sustain a long-term income growth for its population. IMF and World Bank estimate that continued developments in this direction can easily result in Russia falling into a "Dutch disease" type of classic economic crisis as soon as oil prices drop.[207]

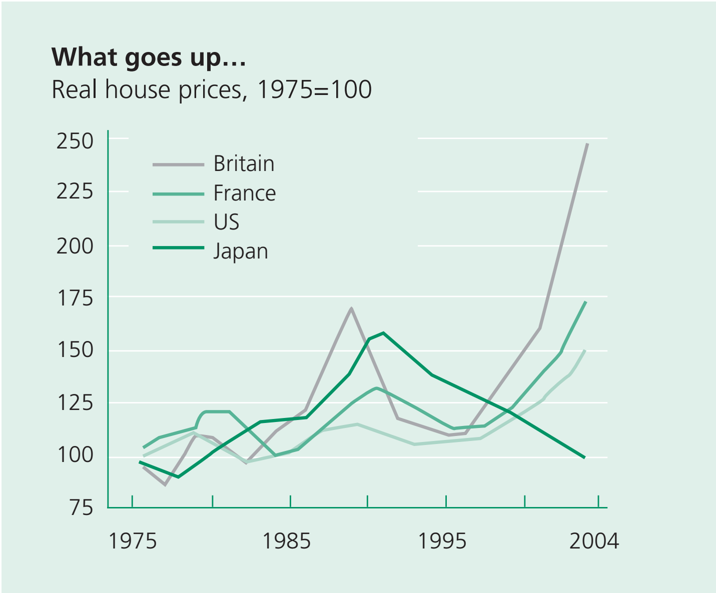
In the light of relative economic stagnation of the Western countries, recent years have witnessed a massive flow of portfolio investments and cheap debt financing into the comparatively faster growing economies of the developing markets, causing rapid increase in local stock exchange indices.[208] Even if at first sight this looks like a fairly positive development for the several new member states of the European Union, their high current account deficit and heavy external debt burden still imply possible threat of instability. Having to fight speculative attacks against forint three times in 2003 and the decision by the Hungarian central bank to raise the base rate of forint to 10% level in order to refinance public sector external debt indicate that their situation is one of the most complicated in the whole region.[209]

[207] Karoly Attila Soos *et al*, "Russian manufacturing industry in the mirror of its exports to the European Union", *Russian Economic Trends*, 11, 2002, 31-43; "IMF tells Russia to focus on inflation, not growth", *Agence France Press*, 17.11. 2004, http://uk.biz.yahoo.com/041116/323/f6qqr.html.

[208] In 2004 Bratislava stock exchange index climbed 77%, Budapest and Tallinn stock exchange indices each 53%. Prague stock exchange has enjoyed a 49% rise. See "Eastern European bourses enjoy boom", *Agence France Press*, 13.12.2004.

[209] See e.g. *Economic Survey of Europe, 2004 issue 1*, New York: United Nations Publications, 2004, 51-52.

Figure 34. **Real house prices, 1975 = 100.**



Source: „The global housing market: Flimsy foundations", *The Economist*, 09.12.2004.

Although there have been other real estate booms in history, the hyper-low base rate of leading currencies has this time triggered a truly global real estate boom. Rapid growth in debt burden has nurtured the escalation of the real prices of real estate in Britain by 2.5 times from the 1997 level; the increase has been slightly lesser in France and USA. (Figure 34) Real estate prices have also gone through a significant expansion in Australia, Ireland and Spain, several Central and Eastern European countries and elsewhere. Yet economy is cyclical in nature, so every upsurge is quite certainly followed by a period of decline.

Seeing as growth in real estate prices has been a global phenomenon, IMF projects that the setbacks in the economy to be brought about by rising interest rates and decline in prices will also occur globally.[210]

Even economic theorists are no more as convinced of the economic laws that were still deemed bullet-proof just a couple of years ago. Paul Samuelson, one of the founding fathers of modern economic theory, for instance, whose textbooks most contemporary macroeconomic experts have once studied from, is one of those who refers to the works of David Ricardo and John Stuart Mill and calls it "the popular polemical untruth" to assume that the (US) economy always profits from globalisation and free trade.[211]

Along the same lines, in South America the current "Washington Consensus" based reform policy is increasingly viewed as a failure. In order to gain more clout in global policy arena 12 countries have come to an agreement to launch already by the year 2019 a *South American Community* modelled following the example of the European Union and including a regional parliament, common market, common currency etc.[212]

We do not know what kind of solutions the above-mentioned trends in the world economy, policy and research will lead to,[213] but all of these as well as many other socio-economic, technological, environmental and other global trends will most certainly have a significant impact on the future of Estonia too. Although

210 *World Economic Outlook*, IMF, September 2004, 71-89; About the connection between economic cycles and real estate price fluctuations see Ronald Kaiser, "The Long Cycle in Real Estate", *Journal of Real Estate Research*, vol. 14, 3, 1997, 233-257.

211 Paul A. Samuelson, "Where Ricardo and Mill Rebut and Confirm Arguments of Mainstream Economists Supporting Globalisation", *Journal of Economic Prospectives*, 18, 3, 2004, 135-146.

212 *Declaración del Cusco sobre la Comunidad Sudamericana de Naciones III Cumbre Presidencial Sudamericana*, 8. December 2004, http://www.comunidadandina.org/documentos/dec_int/cusco_sudamerica.htm; John Williamson, *From Reform Agenda to Damaged Brand Name: A short history of Washington Consensus and suggestions for what to do next*, Finance & Development, IMF, September 2003, http://www.imf.org/external/pubs/ft/fandd/2003/09/pdf/williams.pdf.

we are not able to control the external environment, relying on good luck alone for future progress is still one of the riskiest strategies to pick. Analysing various future developments helps to better prepare long-term strategies, increase readiness to act in various circumstances and hopefully also to guard, at least somewhat, against unpleasant surprises.

After World War II, guided by this very same insight, *RAND Corporation* started keenly mapping potential future threats, and elaborating respective development scenarios for the purpose of enhancing American military planning. In the 1970s Japan adopted several of the foresight methodologies used in the US, and applied them extremely successfully at the service of technological and socio-economic development. Inspired by Japan's post-war economic miracle majority of developed countries, including China and others have made more or less sound attempts at using various foresight methodologies. Even though it is not the goal of foresight to predict the future, a professionally managed process that includes a broad range of experts does help bringing closer the understandings of various groups of society about their desired future, and thereby incorporates an element of self-fulfilling prophecy.[214]

4.2. European Union and shifts in international division of labour

Economic theories have basically always followed the principle of a positive relation between welfare and market size. This principle became famous through the works of Adam Smith.[215] Accordingly, enlargement of the European Union opens up many new opportunities. Larger markets and lower production costs offer tremendous prospects for growing trade flows, investments and economic development all across Europe. Then again, the European Union brings together economies with dramatically diverse levels of income and development,[216] which raises fundamental questions about the whole possibility of establishing policies that fit all member states simultaneously, and about interdependencies between various states.

Enlargement of the European Union lets Western European companies relocate their production units that struggle with price competition, and offers greater economies of scale. At the same time, these developments offer new member states the much needed access to larger market, capital and technology.[217]

Prima facie, largest ever enlargement of the European Union that added ten more countries is therefore also very good news for Estonian entrepreneurs and the economy as a whole. Taking advantage of the opportunities offered by the enlargement is, however, altogether not that easy. Low income levels of their population make new member states still a less attractive destination market for investors as compared to Western Europe. In addition, markets of the new member states are not very large on their own, except for maybe Poland. Although the income levels in Central and Eastern European countries have generally followed the productivity growth trends, and the latter have been significant ever since 1991, the persistently modest productivity levels do not allow for rapid increase in incomes.

Starting with David Ricardo, the concept of *comparative advantage* that results from differences in labour productivity has been the classic approach to explaining international trade. Ricardo believed that differing productivity levels between various countries arise from the countries' economic environment or "climate" that favours one or another activity. Since every economic environment always favours some activities more

213 An example of a very current issue would be the continuously growing oil prices and projections about the remaining fossil fuel reserves. Just like during the oil crisis of the 1970s, development of alternative technologies for energy production has once again established its presence on global agenda. Whilst in the 1970s it was thought that technology-wise we are only 20 years away from hydrogen solutions, virtually the same projection still applies today, since there have been no major investments into this sector during the intervening years. For a more detailed account of the developments in this field see „Hydrogen not a solution for the short term, says UK economist", *EurActive.com*, 13.10.2004, http://www.euractiv.com/Article?tcmuri=tcm:29-130838-16&type=News&_lang=EN.

214 See e.g. Denis Loveridge, *Foresight: A Guide for Sponsors, Organisers and Practitioners*, PREST, University of Manchester, 1999; James Gavigan *et al, A Practical Guide to Regional Foresight*, FOREN network, 2001.

215 About the specifics of economic policy in small states see e.g. E.A.G. Robinson (ed), *Economic Consequences of the Size of Nations*, London: Macmillan, 1963.

216 Julie Pellegrin, *The Political Economy of Competitiveness In an Enlarged Europe: Who Is In Charge?*, http://www.ciaonet.org/isa/pej01/; see also Julie Pellegrin, *Political Economy of Competitiveness in Enlarged Europe*, Palgrave Macmillan 2001.

217 Julie Pellegrin, *The Political Economy of Competitiveness In an Enlarged Europe: Who Is In Charge?*, http://www.ciaonet.org/isa/pej01/.europa.eu.int/comm/enterprise/enterprise_policy/industry/doc/sec_234_200n.d

than others, it is, of course, more profitable for the entrepreneurs to rather invest in activities that offer better revenue opportunities. Investment decisions made by entrepreneurs are thus dependent upon government actions in developing the economic environment.[218] This logic is the very basis of the understanding that the European Union, just like any other free trade area, is beneficial for the associated countries under the conditions of competent/successful specialisation.

Analyses of the impact of the European Union enlargement upon future international specialisation primarily highlight two groups of industries. In the sectors where trade between Western Europe and Central and Eastern Europe was more or less in balance prior to enlargement, larger economies of scale are expected to bring about additional economic growth for both regions. On the other hand, Baldwin, Francois, Portes et al believe that in those sectors where Western Europe has so far had significant surpluses in trading with Central and Eastern Europe (e.g. chemical, rubber and plastic products, means of transportation, and various capital goods etc) the latter will drop out of competition as soon as markets are fully opened up. Biggest winners in this whole situation are countries that are involved in the export of these goods to Central and Eastern Europe.[219]

European agreements extended the common market of the European Union to virtually all manufacturing products of new member states already on January 1st 1995. Estonia, in turn, abandoned all trade barriers. Hence it is exactly the above described trend that we have been witnessing during the second half of the 1990s, even if it has been somewhat alleviated by the growth rates in services sector.[220] Future impact of the European Union membership is therefore mostly limited to the full application of the *acquis* etc (see also Ch. 3.3 and 4.3), and does not really generate much change in trade discipline anymore.

Although a larger market does allow for more specialisation, both the above and historic experiences have clearly demonstrated that free movement of capital, goods, services and labour itself does not ensure automatic convergence in the standards of living. By the same token, membership of the European Union has not led to convergence in the standards of living of most of the low technology specialised "cohesion countries" in the Union's periphery with those of the core countries regardless of massive investments into regional policies.[221]

Development of the former Eastern Germany emerges as one of the most drastic examples of the latter situation. It should be one of the most positive examples of integration since it received massive investment flows from Western Germany, and not only did both parts of Germany fully open their markets to each other, but their labour, social and other policies were also harmonised in the process of adopting the institutional structure of Western Germany. Yet the rejoining of the two Germanys, which cost 1,250 billion euros, has basically led to catastrophic outcomes. One of the most conspicuous trends is the emergence of rapidly developing economic oases in random cities surrounded by rapid stagnation and massive unemployment.[222]

218 The theory of comparative advantage assumes that the economic environment of different countries varies in regard to the availability of factors of production, i.e. land, labour force, natural resources, and capital. Contemporary versions of this theory often focus on only one factor of production – labour productivity in various countries. Unfortunately, these approaches completely discard such important factors for economic development as technological change and economies of scale. In addition, the theory of comparative advantage completely overlooks several cross-border effects that are extremely improtant for a small country, e.g. intra-industry trade and foreign investments. For a more detailed account see Dornbusch 1977; Michael E. Porter, *The Competitive Advantage of Nations*, London, Macmillan, 1990, 11-21.

219 Frank Barry, Aoife Hannan, *Will Enlargement Threaten Ireland's FDI Inflows?*, Quarterly Economic Commentary, Economic and Social Research Institute, Dublin, December 2001, 55-67, 55; Richard Baldwin, Joseph F. Francois and Richard Portes, "The Costs and Benefits of Eastern Enlargement: The Impact on the EU and Central Europe", *Economic Policy*, 12.04.1997, 125-176.

220 Some exceptions were made towards steel, coal and textile products where free trade was implemented to the full extent only somewhat later. See *Impact of Enlargement on Industry*, SEC(2003) 234, European Commission, 2003, 5.

221 While the rich Western European countries were actively specialising and concentrating their labour into high productivity sectors, Eastern Europe and Baltic states were gradually becoming the suppliers of raw materials and agricultural produce already in the 16th-17th centuries. See e.g. Angus Maddison, *The World Economy: Millenial Perspective*, OECD, Pariis, 2001, 75-80; Daniel Chirot (ed), *The Origins of Backwardness in Eastern Europe. Economics and Politics from the Middle Ages Until the Early Twentieth Century, University of California Press*, 1991.

222 See *Der Spiegel*, http://www.spiegel.de/politik/deutschland/0,1518,294097,00.html.

This kind of uneven domestic development is characteristic of not only Germany or Europe. *New York Times* and *Business Week* observe a swift decline in the wage levels of American middle class, which indicates the emergence of peripheries in other very highly developed countries as well, and essentially confirms the fact that industry clustering is no more chiefly linked to geographic location.[223] While a quarter of the US labour force is trapped in low-wage jobs with no real prospects for advancement, there is a massive outflow of jobs into Asian countries that have relatively low standards of living. (About technological development and relocation of economic activities see also Ch. 1.4). It is not only the cheaper functions, but also the relatively technology-intensive activities that are being relocated. *Boston Consulting Group, RAND Corporation* and other well-known analysts point to the share of more complex manufacturing processes rapidly moving to China, because there the production allows for less automation and more use of cheap skilled labour force, instead.[224]

If other countries, including Estonia, were to try and uphold their current, mostly price-based competitive advantage by competing with China, for instance, on the same grounds, then the only further competitive advantages could obviously be even cheaper labour, lower taxes, weaker educational and social system etc. Altogether this strategy is called "race to the bottom".[225]

Adam Smith was prompted into writing about the wealth of nations by the stratification and poverty he witnessed in England, the country that he scornfully called 'a merchant state'. Contrary to mercantilists who were convinced that the majority will need to remain poor and ignorant for the sake of the happiness of the society as a whole, in *The Wealth of Nations* Smith described the welfare of all members of a society as an essential starting point for the evolution of capitalist market economy.[226] History offers plenty of examples about an unjustly large social inequality sooner or later leading to the overthrowing of existing rulers or, even worse, to a desire for a strict order, and to the disappearance of a free and democratic society.[227]

The United States President Abraham Lincoln's Civil War policy of uniting the northern and southern states with the intention of facilitating social mobility and technological development, and putting the countries interests above those of small groups has proven a much more effective approach to increasing general social well-being. This is the very reason why the United States is still known as a land of opportunity where every paper-boy can become a millionaire.[228]

The policy of doing nothing or ignoring the structural problems of the economy and social disparity does not facilitate the emergence of any attractive development prospects for the future of Estonia. The model of the *Lisbon strategy* stresses that in addition to increasing the international competitiveness of companies, public policy developers must pay much more attention to the well-being of the society as a whole – Estonia is competing in the European Union not only with its products and services, but also with its capacity to offer an attractive social environment where people would actually like to live. At the end of the day, it is precisely the latter that enables a country to attract more foreign investments, which, in turn, lead to more favourable conditions for generating additional high-wage jobs; simplify access to international markets, high technology, capital etc.

223 See e.g. "The Wal-martization of America", *New York Times editorial*, 15.11.2003; Aaron Bernstein, "Waking up from the American Dream", *BusinessWeek*, 01.12.2003; Elieen Appelbaum *et al*, *Low-wage America: How employers are reshaping opportunity in the workplace*, Russell Sage Foundation, 2003.

224 *Made in China. Why Industrial Goods are going next,* The Boston Consulting Group, 2003.

225 China is witnessing massive urbanisation, and economic development is progressively speading from the coastal areas towards the inland. Even the relatively high social imbalance is now more easily tolerable since the incomes of even the poorest segment of population are increasing. People are more optimistic about the future of their children than they used to be.

226 Adam Smith, *The Wealth of Nations,* London, Campbell, [1776] 1991, Book I, VIII.

227 Although Aristotle believed that one kind of people was born to rule and the other kind to obey, he warned already in 350 BC in his *Politica* (see book V, IX) against excessive disproportions in any society, which he considered dangerous for both rulers and the social order. See also Robert Heilbroner, *The worldly philosophers. The lives, times, and ideas of the great economic thinkers*, Touchstone Books, 7th edition, 1999, 40-74; Fareed Zakaria, *The Future of Freedom: Illiberal Democracy and Home and Abroad*, W.W. Norton Company, New York & London, 2003.

228 Robert Hormats, "Abraham Lincoln and the Global Economy", *Harvard Business Review*, August 2003, 58-68; Aaron Bernstein, "Waking up from the American Dream", *BusinessWeek*, 01.12.2003.

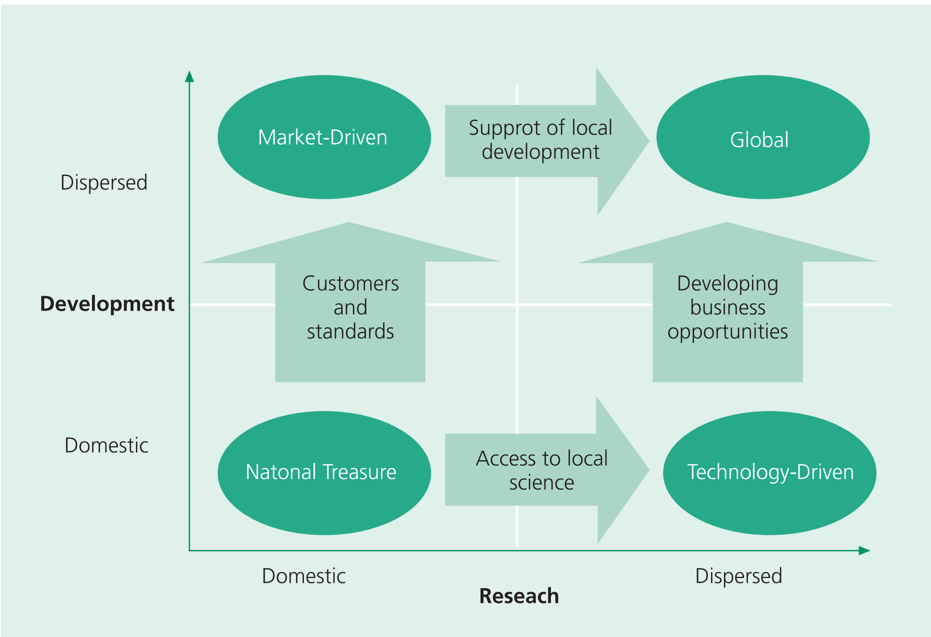
The following scenarios thus assume that Estonia will be experiencing further development with no excessive social disproportions. The focus is on the type of economic specialisation that is needed for job creation and higher income generation, or, in other words, on restructuring the economy towards more research and technology-intensive activities. These possible developments described in the scenarios below are not at all mutually exclusive. We also make no attempt at assessing the likelihood of their attainability, which largely depends on Estonia's own decisions or lack of decisions in the upcoming years.

Prior to setting off to resolve the structural problems of Estonian economy and labour market it is important to have a rather clear vision about the type of economic structure and the role we actually want Estonia to have in Europe (the world) in the coming 10-20 years, and what pattern of specialisation this requires from education, research and other sectors. Although there is now way to actually predict the future, Estonia still needs a good long-term vision of how to confront the impending demographic and socio-economic challenges.

4.3. Scenario I: Scandinavian periphery

Internationalisation of research and development is mostly driven by the desire of companies to get better access to foreign technologies or to adapt their own produce to the specific requirements of foreign markets, to their standards etc. (Figure 35) Special attention should be paid to the activities of large countries and multinational corporations, since they are the ones dominating the high technology market and investments into research and development. About 30-40% of contemporary global trade is really intra-firm trade, i.e. it takes place within the production and sales networks of international companies.

Figure 35. **Major trends and factors in the internationalisation of research and development.**



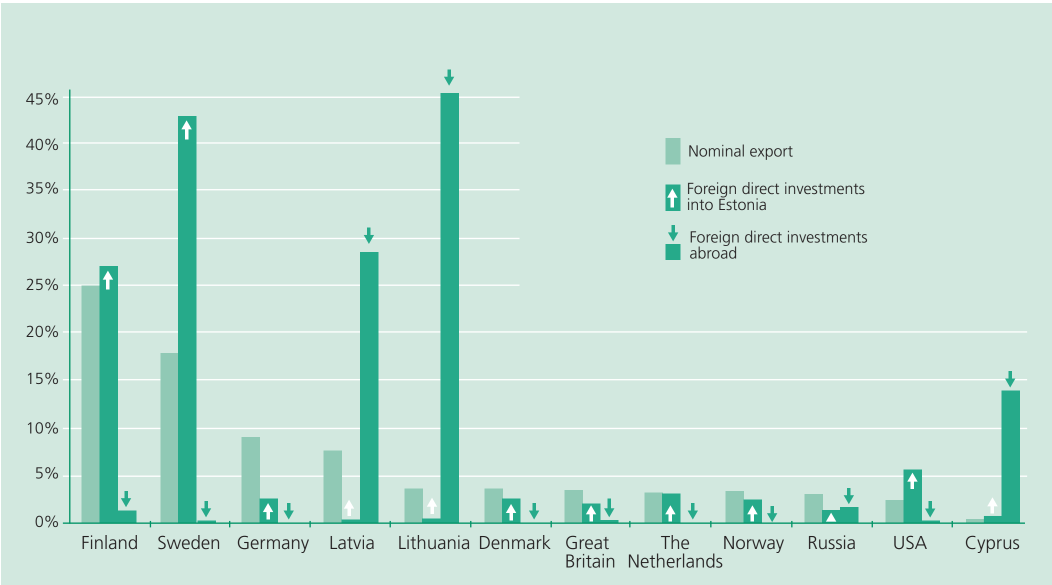
Source: Maximilian von Zedtwitz and Oliver Gassmann, "Market versus technology drive in R&D internationalization: four different patterns of managing research and development", *Research Policy*, 31, 2002, 569-588, 581.

A professionally devised foreign investment strategy allows a country to achieve quite drastic changes in the structure of industry and the whole economy in a rather short time span. Good timing, availability of modern infrastructure (incl. education and research) and suitably qualified labour force as well as a fair amount of good luck are all critical to success. Favourable tax policies and government's financial subsidies alone do not really play that great a role in the pursuit of more research and technology intensive investments. Multinational corporations treat them as additional benefits rather than primary decision criteria.[229]

Irish experiences after joining the European Union are also a good evidence of how the geographic and sectoral distributions of post-accession foreign investment flows might not resemble that of the pre-accession investment flows. The Irish were quite fortunate to have the post-accession investments flow into notably different sectors from what used to be their economic specialisation. Although Ireland did not have any competitive advantages in the chemical and metal manufacturing sectors prior to joining the European Union, it was precisely these sectors that developed fastest after the accession due to massive foreign investments they received.[230]

Within the 1990s Estonia has really grown into a coherent part of Nordic international economic clusters. 70% of the foreign direct investments that came to Estonia as of the end of 2003 originated from Finland and Sweden. In 2003 the most important countries of destination for Estonia's basic exports were also Sweden and Finland. Estonia's own foreign direct investments were mostly targeting Latvia and Lithuania. Financial sector was responsible for 2/3 of the foreign direct investments originating from Estonia. (Figure 36)

Figure 36. **Most important countries of destination for Estonia's basic exports, and the structure of Estonia's foreign direct investments by countries, 2003.**



Source: Statistical Office of Estonia, Bank of Estonia, June 2004, calculations by authors.

Compared to other Central and Eastern European countries in 1999, companies with 10% or more foreign capital were clearly most dominant in Estonian industries. Even though only less than a third of all companies included foreign capital, the latter were responsible for more than 90% of Estonia's total sales

229 Cees van Beers, *The role of foreign direct investment on small countries' competitive and technological position*, Government Institute of Economic Research, Helsinki, 2003.

230 Frank Barry, Aoife Hannan, Will Enlargement Threaten Ireland's FDI Inflows?, *Quarterly Economic Commentary*, Economic and Social Research Institute, Dublin, December 2001, 55-67, 55; Frank Barry, Aoife Hannan, *FDI and the Predictive Powers of Revealed Comparative Advantage Indicators, 2001, manuscript,* http://www.ucd.ie/~economic/staff/barry/fdi.html.

and investments into research and development. The relatively higher share of local capital based enterprises in manufacturing employment implies significantly higher productivity levels in companies that include foreign capital.[231] (Table 13)

It is thus possible to examine Estonia's prior and potential future developments using the "flying geese" model that has been very popular in analysing the rapid development of South East Asian countries. According to this model, rapid economic development in a developed country and the gradual relocation of its economic activities in the neighbouring countries facilitates economic development in the latter too. As the standard of living increases and the relative cost advantages fade away the catching-up country will start abandoning the less knowledge and technology intensive economic activities.[232]

Table 13. **Foreign investment based vs local industrial enterprises, 1999.**[233]

	Bulgaria	Czech Republic	Estonia	Hungary	Lithuania	Latvia	Poland	Romania	Slovakia	Slovenia	Average
Total number of companies	1334	1168	373	360	171	194	1540	1711	151	1093	801
incl. FDI based:	95	191	108	84	6	36	198	289	9	118	113
% of total number of companies	7.1	16.4	29.0	23.3	3.5	18.6	12.9	16.9	6.0	10.8	14.4
% of sales	26.6	62.3	92.1	96.4	9.1	51.7	53.3	30.9	8.5	38.0	46.9
% of employment	15.2	30.0	56.0	48.9	3.4	31.6	18.8	19.4	6.2	17.3	24.7
% of R&D Investments	33.7	34.8	90.1	36.9	18.0	19.0	56.5	32.1	32.7	14.5	36.8
Ratio of income level to that of local companies	1.73	1.34	1.41	1.31	1.00	1.00	0.74	1.21	1.25	1.16	1.22

Source: Jože P. Damijan *et al*, *Technology transfer through FDI in TOP-10 transition countries: How important are direct effects, horizontal and vertical spillovers?*, Institute of Economic Research, Working Paper 17, Ljubljana, February 2003.

Because of the significant role of the foreign capital it is useful to explain the prior structural changes and the possible future trends in Estonian economy via the description of the development and expansion of Nordic economic clusters. Development of Finnish economic clusters basically reflects the structural changes in Estonian economy:[234]

- The share of **timber and forestry cluster**, incl. furniture production, publishing and printing as well as the currently still moderately successful paper production, more than doubled in Estonia within the period of 1992-2002, now amounting to 27% of Estonia's manufacturing produce. International trade indicators suggest that alongside with the fuel transit and textile industry this cluster is really one of Estonia's primary comparative advantages.[235]

[231] See also Helena Hannula and Katrin Tamm, "Restructuring and Efficiency in Estonian Manufacturing Industry: The Role of Foreign Ownership", University of Tartu, *Faculty of Economics and Business Administration Working Paper Series* 15/2002.

[232] Kaname Akamatsu, „Waga kuni yomo kogyohin no susei" [Trend of Japanese Trade in Woolen Goods], *Shogyo Keizai Ronso, 13, 1935, 129–212; Kiyoshi Kojima, „The „flying geese" model of Asian economic development: origin, theoretical foundations, and regional policy implications", Journal of Asian Economics, 11, 2000, 375-401; Jože P. Damijan and Matija Rojec, Foreign Direct Investment and the Catching-up Process in New EU Member States: Is There a Flying Geese Pattern?, WIIW Research Reports 310, October 2004.*

[233] These numbers represent the data from manufacturing companies with 100 and more employees (As an exception, the data about Slovenia include companies with 10 and more employees). The data about Estonia are from the year 1998.

[234] See also K. Alho, C. Hazley, Hannu Hernesniemi, M. Widgrén, *The Effects of the Eastern Enlargement of the EU on Production Structure in Finland*. ETLA Discussion Paper No 752 (in Finnish), ETLA 2001.

[235] See also Urnas Varblane and Kadri Ukrainski (eds), *Eesti puidusektori konkurentsivõime* [Competitiveness of Estonian wood industry], Tartu University Press, Tartu 2004; Doris Hanzl, Waltraut Urban, *Competitiveness of Industry in CEE Candidate Countries: Forest-based Industries*, Vienna Institute for International Economic Studies, Vienna, 2000.

As a positive trend, processing of raw material in Estonia is increasingly replacing exports of raw timber. Estonian forestry sector is tightly integrated into the broader Scandinavian forestry cluster via ownership and trade relations.[236] Nordic companies are primarily interested in the Baltic countries as suppliers of raw material, and also as a suitable location for labour-intensive production in close proximity to the export markets of continental Europe. At the same time we find the higher value adding activities like production and design of wood and timber processing machinery and of high quality paper to be dominant in Finland and Sweden.

Environmental protection requirements of the *acquis* have a considerable impact on Estonian and Latvian wood processing industries, yet the readiness of their companies to actually comply with these requirements is relatively low. It is therefore likely that the companies not able to update their technologies fast enough will either end up in foreign ownership or will have to terminate their activities.[237]

- **Food industry** is one of the most important sectors both in regard to volume of production and employment in Estonia as well as in most of the other new member states of the European Union with its total share amounting to nearly 25% of manufacturing produce in Poland and the Baltic countries. In Estonia, this indicator has plunged from 32% in 1992 to only 17% in 2002. In spite of that, it is still a fairly important sector for Estonian economy accounting for 20% of total manufacturing employment.

Although the Baltic countries with their cheaper raw materials and lower labour costs are direct competitors to Finland, Finish entrepreneurs also see good investment opportunities in launching their own production in this area that will carry their brand names. Indeed, foreign capital already has about 25% share in Estonian food industry. Since complying with the requirements of the European Union is very costly in food industry and readiness for this very low in the Baltic countries, it is to be expected that also in this industry several of the companies currently owned by domestic capital will likely be transferred into foreign ownership.[238]

- The share of **textile and garment industry** in Estonian manufacturing produce has also halved within the past 10 years, yet still accounting for 10% of manufacturing produce and 18% of manufacturing employment in 2002. Textile industry is not expected to have significant problems in complying with the requirements of the *acquis*, but instead, it is struggling with growing labour costs of sewing work, and small volumes that do not support the use of subcontractors from India or elsewhere.

Due to increasing labour costs and elimination of international trade barriers the only real prospects remaining for this industry are close collaboration and clustering with other industries (e.g. furniture production), focusing on specific high technology and knowledge intensive produce (e.g. production of fabrics with special qualities, garments with embedded information technology and the like).[239]

- **Manufacture of metals and metal products** constitutes 7% of manufacturing produce. Since this is generally an extremely capital-intensive field, it would be difficult for Estonian companies alone to compete on a global scale. Foreign capital is present in 21% of the companies of this sector. On the other hand, it is rather likely for a certain section of the activities that are loosing their cost advantages in Scandinavia (e.g. production of specific parts of various machinery and equipment) to be gradually relocated into the Baltic countries.

236 The share of foreign capital in Estonian wood processing industry is no less than 57%, and is 13% in furniture industry. See Evis Sinani, Klaus Mayer, *Identifying Spillovers of Technology Transfer from FDI: The case of Estonia*, Copenhagen Business School, April 2001, 26.

237 Peter Havlik, *Competitiveness of Industry in CEE Candidate Countries*, European Commission, DG ENTR, February 2002, http://www.wiiw.ac.at/pdf/competitiveness_composite.pdf.

238 *Ibid*; Statistical Database, Statistical Office of Estonia, 2004, http://www.stat.ee.

239 Large part of Mexican textile industry is also moving into China, where workers only make 0.68 USD an hour instead of the 2.45 USD in Mexico. About the impact that the removal of international trade barriers has had on textile industry see also: *A New World Map in Textiles and Clothing: Adjusting to Change*, OECD, Paris 2004; "The textile industry: The looming revolution", *The Economist*, 11.11.2004; Paul Magnusson, „Who'll Survive The Textile Trade Shakeout?", *BusinessWeek*, 20.12.2004.

240 Tarmo Kalvet, *The Estonian ICT Manufacturing and Software Industry: Current State and Future Outlook*, Institute for Prospective Technological Studies - Directorate General Joint Research Centre, European Commission: Sevilla, 2004, http://www.jrc.es/home/publications/publication.cfm?pub=1200.

- **Information and communication technology**, incl. manufacture of electrical equipment, optical and precision instruments, constitutes approximately 6% of Estonia's manufacturing produce, notwithstanding its enormous share in exports. Thereby Estonia is of interest to Sweden and Finland both as a new emerging market and increasingly also as a fairly convenient host country for labour-intensive assembly processes of electronics industry. The *Elcoteq* plant in Tallinn is no more alone with a whole range of smaller electronics producers now relocating their production to Pärnu, Elva and elsewhere in Estonia.[240]

- The share of **chemical industry** in manufacturing produce has also halved from the 1992 level, now accounting for a modest 4%. Foreign capital is present in 20% of enterprises engaged in oil and chemicals production, and 57% of the enterprises engaged in rubber and plastic production. Chemical industry is struggling to comply with the requirements of the *acquis* in the sections of common market and environmental regulation.

- **Construction and manufacture of construction materials** in Estonia is both a promising new market and a source of relatively cheap labour for Nordic companies. Due to logistic reasons it is precisely the countries close by that are more attractive to Finish and Swedish investors. Even though real estate and construction sector has experienced rapid progress over the past years, exhaustion of the global real estate boom can lead to serious setbacks in this sector, which can cause increased unemployment and other negative developments.

- **Transport**, but most particularly the east-west transit (e.g. oil transit from Russia to Western Europe) industry competition with neighbouring countries is mostly related to the efficiency of logistic systems, i.e. low costs. Bearing in mind the vigorous expansion of the ports of St. Petersburg, one of the key options for enhancing the competitiveness of the transit corridor or increasing the added value generated in Estonia is clearly the development of local manufacturing or the industry of processing raw materials and products in transit.

Since several Estonian low and medium technology industries have problems with fulfilling the requirements of the *acquis*, and it is generally typical of these fields to experience gradual concentration of economic activities, then we can expect Scandinavian investors to show heightened interest to take over Estonian companies that operate in those fields. This has already occurred in the financial sector, and is now also happening in timber and food industries and in the production of metals and metal products.

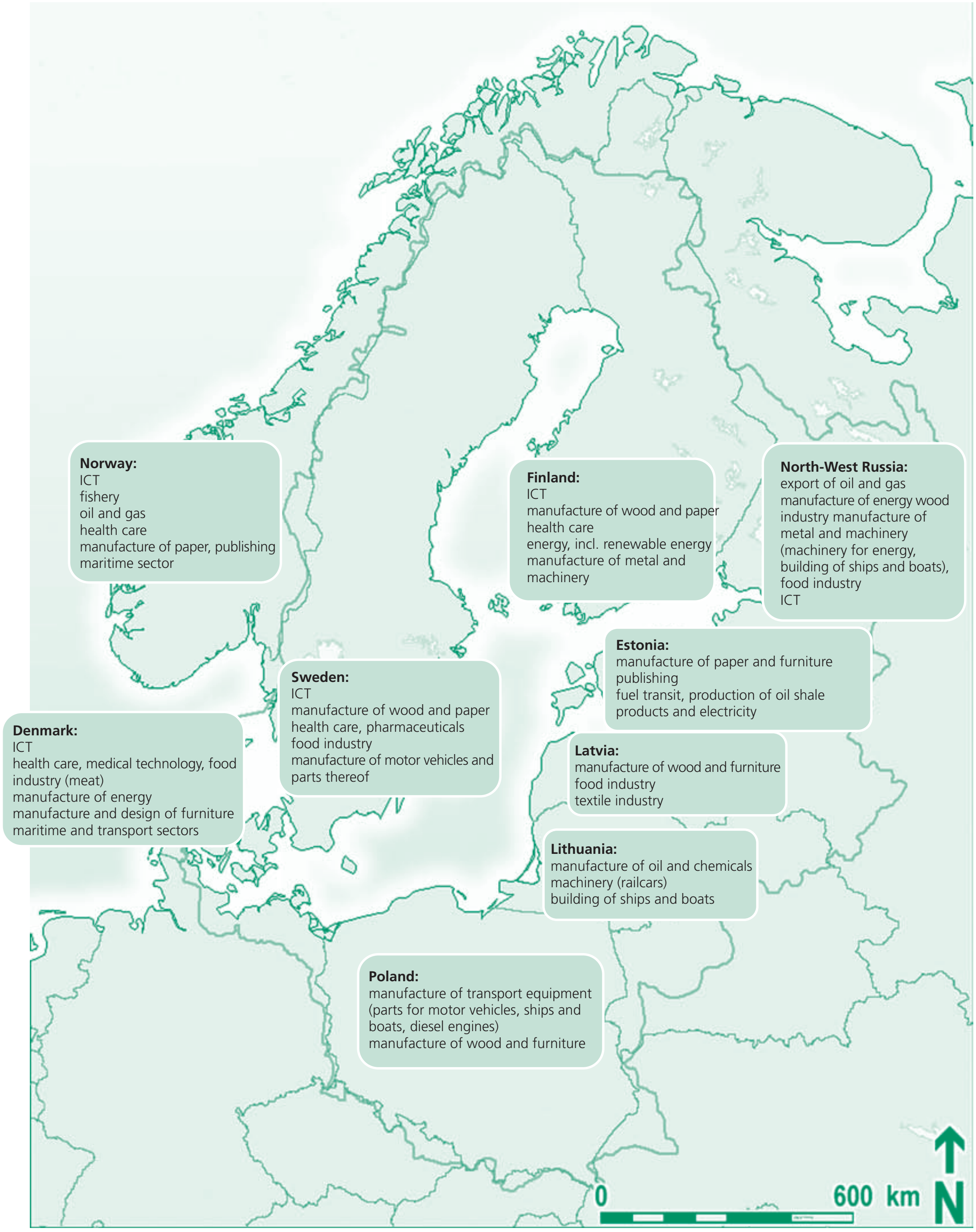
In consideration of Estonia's future, however, there is really no reason to focus on the economic integration with Finland and Sweden alone.[241]

In the global economy Finland and Sweden are certainly competitors. Their specialisation profiles are pretty similar in regard to both transport and telecommunication systems sector. Even if Finland does have a better innovation and business environment, Sweden is simply larger and therefore has a much broader competence base needed for structural changes. While Helsinki has closer ties with Estonia due to geographic proximity, Stockholm strives to strengthen its role as a geographic centre of the Baltic Sea region. Geographic advantages render the endorsement of cooperation between Finland and Sweden just as likely.[242]

241 Comparison of the added value of Estonian exports across countries shows that Estonian export to Sweden and Finland is siginificantly less profitable in comparison with other countries of destination. In addition, contribution of exports to Estonia's economic growth has declined over the period of 1994-2001. In 2001 the average contribution of one unit of exports to Estonia's GDP is down 19% from the 1994 level in case of the exports to the European Union; the relevant indicator is 28% for the exports to Finland, and 12% for the exports to Sweden. See Ülo Kaasik, *Eesti eksporditoodete lisandväärtus* [Added value of Estonian exports], Working Papers of Eesti Pank, no 3, Tallinn 2003, 9.

242 Kai Böhme, Åge Mariussen, Lars Olof Persson, „Strategies for competition and co-operation between metropolises in the Baltic Sea region", Regional Studies Association, Gdansk, Poland, 15-18. September 2001.

Figure 37. **Economic specialisation in the Baltic Sea region.**



Source: Nordisk cluster mapping, Oxford Research, January 2002; UNCTAD/WTO International Trade Centre, February 2005, http://www.intracen.org; adjustments by the authors.

Seeing as Berlin and St. Petersburg are historically the most important cities in Northern Europe, both Stockholm and Helsinki are very much interested in cooperation with the North West part of Russia, which is rich in human as well as natural resources.[243] Today St. Petersburg is an emerging centre for international trade and tourism. It is quite likely, then, that in the long run St. Petersburg and Berlin will restore most of their former prominence and will become the principal trade centers between east and west.[244]

A prerequisite to this development is the emergence of an innovation system that integrates the research and technology environment of St. Petersburg with Western technologies, industries and global markets. It is quite possible that in future St. Petersburg will play a significant role in information and communication technology sector, thus becoming a strong competitor to Finland and Sweden.[245]

The integrated region of Øresund is making also Denmark an increasingly important player in the Baltic Sea transport sector. Moreover, the Øresund region has a great potential for developing a knowledge-based economy in information technology, biotechnology, new media as well as medical sectors.[246] Hamburg, Warsaw, Berlin, but also the Øresund region, devote rather limited attention to the Baltic Sea region in view of their own development. These metropols have focused their development efforts more on the relations with continental Europe. Since most of them are also metropols on the European scale, they become rather important for Estonia as centres that drag along the whole Baltic Sea region with the latter possibly functioning as their support base.[247]

In the short and medium term, concentrating on the creation of favourable conditions for receiving foreign investments and technology transfer is probably the most effective way that Estonian economic policy can help secure sustained generation of new jobs and growth in labour productivity.[248]

This implies that in order to be successful in competing with the neighbouring countries Estonia's educational, vocational and retraining systems as well as applied research and development activities need to go through structural adjustments that are consistent with the developments in respective cross-border economic clusters and with the relocation of economic activities within the Baltic Sea region.

Nonetheless, it is important to understand that the influx of foreign investments might not always truly support local entrepreneurship and the socio-economic development of a country as a whole. Various studies conducted in the Central and Eastern European countries suggest that so far the primary interest of foreign investors has been to exploit rather than develop the local resources of host countries. Likewise, current investments from Nordic countries into the Baltic countries have been chiefly driven by the desire to expand domestic markets, i.e. they are mostly focused on the acquisition of market share and resource. There is no reason to criticise the foreign investors for this, though. It is crucial to comprehend, instead, that Estonia's present strategy of providing the foreign companies with a cost-effective environment is, indeed, relatively effective for generating jobs and maintaining a good standard of living, but does not usually offer much opportunity for accelerated development.[249]

243 About developments in St. Petersburg and North-West Russia see Grigory Dudarev, Sergey Boltramovich, Pavel Filippov and Hannu Hernesniemi, *Advantage NorthWest Russia, The New Growth Centre of Europe?* SITRA, Helsinki, 2004, 291, http://www.sitra.fi/Julkaisut/raportti33.pdf.

244 Kai Böhme, Åge Mariussen, Lars Olof Persson, „Strategies for competition and co-operation between metropolises in the Baltic Sea region", Regional Studies Association, Gdansk, Poland, 15-18. September 2001.

245 About the competitiveness and development potential of St. Petersburg region see also Grigori Dudarev, Hannu Hernesniemi, Pavel Filippov, *Emerging Clusters of the Northern Dimension – Competitive Analysis of Northern Russia – A Preliminary Study*, ETLA, Helsinki 2002; Sergey Boltaramovich, Pavel Filippov, Hannu Hernesniemi, *The Innovation System and Business Environment of North-West Russia*, ETLA Discussion Paper no 953, December 2004.

246 Kai Böhme, Åge Mariussen, Lars Olof Persson, „Strategies for competition and co-operation between metropolises in the Baltic Sea region", Regional Studies Association, Gdansk, Poland, 15-18. September 2001.

247 *Ibid.*

248 John Zysman and Andrew Scwartz (eds), *Enlarging Europe: The Industrial Foundations of a New Political Reality*, University of California International and Area Studies Digital Collection, Research Series #99, 1998, http://repositories.cdlib.org/uciaspubs/research/99/; Johannes Stephan, *Evolving Structural Patterns in the Enlarging European Division of Labour: Sectoral and Branch Specialisation and the Potentials for Closing the Productivity Gap*, 2003, 23, http://econwpa.wustl.edu:8089/eps/dev/papers/0403/0403003.pdf

249 *Ibid*; see e.g. Harley Johansen, „Nordic Investments in the Former Soviet Baltic Frontier: A Survey of Firms and Selected Case Studies", *Geografiska Annaler*, Series B Human Geography, 82, 4, 2000, 207-219; Frank Barry, Aoife Hannan, *Will Enlargement Threaten Ireland's FDI Inflows?*, Quarterly Economic Commentary, Economic and Social Research Institute, Dublin, December 2001, 55-67, 56-57; Katrin Männik, „The Role of Foreign Direct Investments in Technology Transfer to Estonia", in Urmas Varblane (ed), *Foreign Direct Investments in Estonian Economy*, Tartu University Press, Tartu 2001, 216.

Unfortunately, most of the economic sectors seeking opportunities for relocation in the Baltic Sea region are increasingly resource and capital intensive fields with only a few well-known brands dominating the global market as suppliers of technology and innovative solutions. Because of the limitations on both scale and recognition of local brands, it would be rather difficult for the Estonian industry to achieve international breakthrough in fields like that. In addition, Estonia's low and medium technology based manufacturing sectors must confront the tightening low-price competition. Local companies will not be able to build the competence base needed for achieving economic independence if they specialise only in the assembly of components mostly produced abroad or in some individual isolated segments of the value chain. The fortunes of the *maquila-industries* in Mexico as well as in Hungary, Scotland (the so-called "dual economies" where the strong foreign investment based companies dominate the market, while domestic companies lag far behind them in regard to productivity as well as capacity to earn profits) over the past decade are all instructive examples of how the foreign investments that target standardised labour-intensive activities prove to be rather mobile as soon as prices increase in the host country in case it does not have any other advantages. These investments will then quickly move on into countries with even lower standards of living like Russia, Ukraine and other regions of the former Soviet Union, but also China.[250]

For the sake of Estonia's future prospects, we should thus be interested in more than tax competition that only focuses on maintaining cost-advantages, and in more than the needs of neighbouring counties with higher standards of living to offshore the less knowledge-intensive functions of their economies into low-cost regions. In order to successfully compete in the global economy it is important to appreciate the strategic trends in the lead countries and their continued efforts to persistently generate new technology-based competitive advantages. The weakness of our independent innovation policy can only lead to the continuation of the south-finlandisation trend described in the future scenarios of *Eesti 2010*, meaning that "Estonia would be leading a life of a servant to Europe".[251]

4.4. Scenario II: Vigorous modernisation of traditional sectors

OECD analyses suggest that about half of the productivity growth in the economies of developed industrial countries results from large-scale application of information technology in industry as well as services sector.[252]

Success of Nokia in the 1990s was largely based on the several decades of intense efforts by the government of Finland to establish domestic industry base. As a matter of fact, Nokia that alone invests about 1% of Finland's annual GDP into research and development,[253] together with the network of its business partners are actually the whole Finnish information and communication technology cluster. Although the scale is not quite the same, the Finnish model of relying on one major corporation has turned out somewhat similar to the Japanese *keiratsu* or Korean *chaebol*-based development model, while the well-being and development of the whole country is fundamentally dependent on the prosperity of one individual large industrial conglomerate.[254]

Yet the coming decade will most certainly not see an uninterrupted continuation of Nokia's current outrageous success. GSM systems are being replaced by the 3rd generation mobile telephony systems – a new field where the division of intellectual property, technology standardisation and growth potential of markets differ radically from the patterns that dominated the world 10-20 years ago. The new mobile communication systems are increasingly complex, plus the intellectual property that is vital to the evolution of the industry is now split between a much larger number of companies than it used to be. (Table 14)

250 See also *Impact of Enlargement on Industry*, SEC(2003) 234, European Commission, 2003, 15.
251 See *Üleriigiline planeering "Eesti 2010*" [Nationwide plan "Estonia 2010"], http://www.sisemin.gov.ee/atp/failid/tais2010.pdf.
252 *The Sources of Economic Growth in OECD Countries*, OECD, Paris 2003, http://www1.oecd.org/publications/e-book/1103011E.PDF.
253 See also *Research and Development in Finland 2004*, Statistics Finland, 2004.
254 Yoon Heo, "Development strategy in Korea reexamined: an interventionist perspective", *The Social Science Journal*, 38, 2001, 217-231; Michael E. Porter, *The Competitive Advantage of Nations*, London, Macmillan, 1990.

This means that due to simultaneous global dissemination of knowledge and technology, growing complexity of information technology systems, and significant expansion in the role of brand names in marketing, an increasing share of research and development activities is moving out of North America and Western Europe into Asia (China, India) and Latin America.[255] Japan and South East Asian newly industrialised countries have already taken or are about to take over the lead from Scandinavia in several technology sectors.[256] The acquisition of *Siemens*' mobile phone unit by BenQ and *Ericsson*'s collaboration with Sony are but a few examples. This trend affects not only mobile connection systems, but also an array of other sectors like displays, data carriers and others that once used to be dominated by the USA or Western Europe.[257] Explosive development is also taking place in China and India that both have enormous population as well as technological and market potential.

Table 14. **Ownership distribution of patents vital to the development of GSM and 3rd generation mobile communications.**

	Number of essential patents	Number of firms holding essential patents	Key players' shares of the essential patents							
			Nokia	Ericsson	Philips	Motorola	Alcatel	Siemens	Qualcomm	Others
GSM	2024	24	41%	360	171	194	1540	1711	151	1093
UMTS	3499	30	27%	84	6	36	198	289	9	118

Source: Petri Rouvinen, Pekka Ylä-Anttila, Little Finland's Transformation to a Wireless Giant, 94, Chapter 5 in S. Dutta, B. Lanvin & F. Paua (eds), *The Global Information Technology Report* 2003-2004, New York: Oxford University Press 2003, 87-108.

Likewise, the St. Petersburg region that is located right next to Estonia has good prospects for combining relatively low costs with rapid development of knowledge-based economy. (Table 15) Research activities in North West Russia are becoming increasingly integrated into western industries and global markets. Several large corporations like *Sun Microsystems*, *Intel*, *Motorola*, *LG Electronics*, *Siemens*, *Togethersoft* (*Borland*) and many others have already bought or established their own research and development centers in Russia. Steve Chase, head of the Russian Intel branch speaks highly of the new distribution of labour: "Give the urgent projects to the Americans, big projects to the Indians, and the impossible ones to the Russians. The Russians can do anything."[258]

[255] According to the estimates of both *Forrester Research* and the European Union, the movement of information technology jobs into regions that offer cheaper (but no less qualified) labour force might lead to a loss of up to 1.2 million jobs in Europe over the next 10 years. These trends will have greatest impact in the United Kingdom, France, Italy and the Netherlands. United Kingdom alone will lose close to 3% of its jobs by the year 2015 as a result of these trends. Expenditure on off-shore services will rise in Europe from the 2004 level of 1.1 billion euros to 3.6 billion euros by 2007. See also David Metcalfe and Sonoko Takahashi, *Two-speed Europe: Why 1 Million Jobs will Move Offshore*, Forrester Research, 18.08.2004; European Foundation for the Improvement of Living and Working Conditions, *Outsourcing of ICT and related services in the EU: A status report*, European Commission, Luxembourg 2004.

[256] Timo Hämäläinen, „Catching-up and forging ahead: Explaing the postwar growth experience in Finland", June 2000, manuscript for publication in the collection *National Competitiveness and Economic Growth: The Changing determinants of Economic Performance in the World Economy*; Dan Steinbock, *Finland's Wireless Valley: Domestic Policies, Globalising Industry*, Tekes, November 2002, http://www.tekes.fi/eng/publications/Finlands_Wireless_Valley.pdf.

[257] Yet there is also evidence of the opposite movement as several Asian investors are trying to obtain technological know-how through the purchase of struggling low and medium technology-based companies as well as research and development labs in Europe and USA. Another reason for this trend is the need of South East Asian companies to ensure a smooth entrance to these markets through a local production base (for instance, Czech Republic has received fairly numerous Asian investments based on this logic, and is now becoming practically „overcrowded").

[258] Sergey Boltaramovich, Pavel Filippov, Hannu Hernesniemi, *The Innovation System and Business Environment of North-West Russia*, ETLA Discussion Paper no 953, December 2004, 40.

Table 15. **Computer programmer's average annual income in US dollars.**

Poland and Hungary	4800 .. 8000
India	5880 .. 11000
Philippines	6564
Malaysia	7200
Russia	5000 .. 7500
China	8952
Canada	28174
Ireland	23000 .. 34000
Israel	15000 .. 38000
USA	60000 .. 80000

Source: Merrill Lynch, „Smart Access Survey", *CIO Magazine*, November 2002.

Even though information technology and electronics produce did constitute approximately 25% of Estonia's basic exports in tbe beginning of 2004, Estonia's domestic information technology industry is still highly unlikely to become a global player any time soon. Then again, the remarkable share that Elcoteq and other Nordic electronics producers have in Estonian exports also indicates an untapped potential. Since the increasingly competitive global electronics production industry is facing decreasing margins, several contract manufacturing companies across the world are now seeking opportunities to move up on the value chain, incl. efforts to launch their own research and product development units. Mobile phone development and production is currently entering the process that is somewhat similar to the way IBM opened up its personal computer platform to other producers many years ago. Whether Estonian companies and research institutions will succeed in finding their own niche within these activities and get the industry to really take root in Estonia will be directly dependent upon their capability to supply the global manufacturing giants with suitable and highly qualified researchers and engineers.

Development of Taiwan's information technology industry is an excellent model of how a country can build up its own industry by supporting the clustering of domestic small and medium-sized enterprises and then linking them up with global production networks where they start out by executing simpler production functions and then move on to providing their own designs to products being marketed under the label of some large company that has significant market power only to try and enter the market one day with their own products carrying their very own labels.[259]

Development of technological competitive advantages is, on the one hand, very much related to earlier investments in education, research and development. Then again, as odd as it initially sounds, it is important that Estonia also learn from the experiences of Taiwan how the currently rather modest investments in industry and technology can be carefully displayed as a strategic advantage. Namely, companies operating in mature industry sectors have an entirely reasonable tendency to protect their prior massive investments in technology and production. This makes them ignore certain new technologies that interrupt existing development paths, albeit these also hold the potential to radically change the rules of the game and business models for the entire economic sector. Although large companies will not give up their positions easily, this still presents a significant opportunity for smartly operating smaller players.[260]

[259] Dieter Ernst, "Catching-up, crisis and truncated industrial upgrading. Evolutionary Aspects of Technological Learning in East Asia's Electronics Industry", UNU INTECH Lisboa Conference, September 1998.

[260] Compare the impact P2P file sharing software had on music and movie industry; or the expected impact of Internet-telephony systems on traditional telephone connection business models.

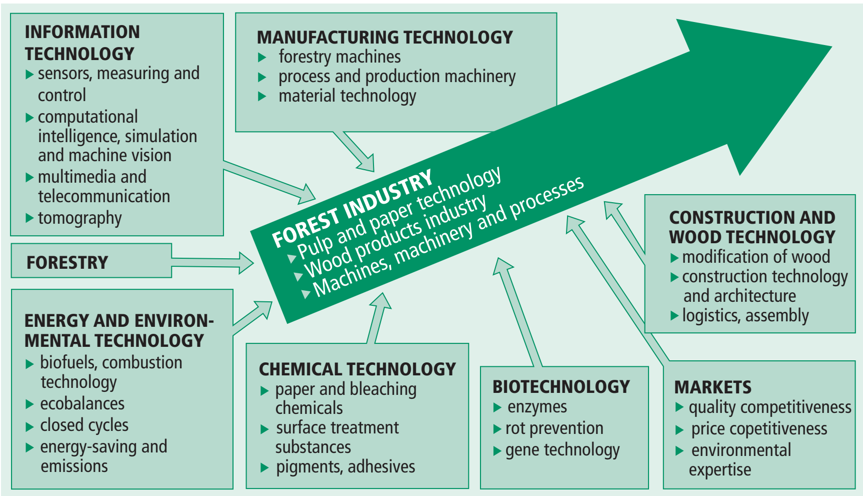
Since Estonian information technology companies generally do not hold prior massive long-term investments, it should give them a certain level of opportunistic freedom to innovate their products, services and organisation in such a way as to help them move into specific new knowledge and technology intensive niches. Systems integrators could thus invest into the creation of certain universal products or services that allow for economies of scale. Microelectronics and electronics industry in general should, on the other hand, analyse carefully various developments in the industry and the technology, and seek out different opportunities, working, for instance, on specific technological breakthroughs in areas like optoelectronics or bio-nanoelectronics etc. (See Ch. 2.4 above)

At the same time it is important to recognise that Finland and Ireland are virtually the only countries in Europe where information technology industry plays an extremely important role in economic development. In the rest of Europe information technology contributes to productivity growth predominantly through broad application of new solutions throughout economy, accompanied by relevant organisational rearrangements.

Although empirical studies confirm that in view of increasing the standard of living it is most useful to try and specialise on the low value-adding end of possibly higher technology based economic activities, development of high technology industry itself entails very high risks for a small country (see Ch. 1.5 above).[261] Taking into account the competitive advantages that Estonian economy possesses today it is particularly important to effectively apply information as well as other new (key) technologies to further augment the existing strengths of forest cluster, food and textile industries, energy etc.[262] (see also Figure 38)

Unfortunately, most of Estonia's traditional sectors currently more or less lack even the basic technological competence needed to advance on the basis of imported high technology. Only government is in the position to take initiative here using public procurement and commissioning to generate initial networks, collaborative formations and products.

Figure 38. **Role of new technology in the evolution of forest industry cluster.**[263]



Source: Alfred Watkins and Natalia Agapitova, *Creating 21st Century National Innovation System for a 21st Century Latvian Economy*, Policy Research Working Paper 2357, World Bank, 2004, 25.

[261] R. Stehrer, J. Wörz, *Industrial Diversity, Trade Patterns and Productivity Convergence*, WIIW Working Papers No. 23, November 2002.

[262] If we still want to have a chemical industry, machinery and other today's medium technology sectors in Estonia in 20 years time, it is critical to foster the capability of Estonian industry and research sector to apply and further renew future bio- and nanotechnology solutions.

[263] About the potential of biotechnology in forestry see also Staffan Laestadius, "Biotechnology and the Potential for a Radical Shift of Technology in Forest Industry", *Technology Analysis & Strategic Management*, 12, 2, 2000.

In the same way, it was the massive investments made in the 1960-70s into technology transfer as well as research and development needed for the development of forest cluster that have made Finland the country with the world's most modern production systems in this field. Production of high quality paper, forestry technology, and relevant consulting services etc today constitute a significant share of Finland's exports. Specific technology programs targeting the exploitation of key technologies to further leverage the sector's competitive advantages has continued to be one of the central elements of Finnish technology policy.[264]

At the same time it would be wrong to limit the thinking of Estonia's future specialisation opportunities to local competitive advantages or those of the neighbouring regions. Development of Swedish steel industry and machinery sector, Nordic mobile telephony as well as Japanese robotics industry are all good examples of how a globally successful manufacturing sector can get started from the investments made into research and technology development to overcome the weaknesses in some specific field. Fast decline in the population size means that it is crucial for Estonia to find more ways to apply new technologies in public administration, educational system, social sphere and other areas.

One such area that has caught more public attention in Estonia is medicine, which is struggling not only with financing and other similar structural problems but (maybe because of the latter) also with massive departure of doctors to other countries. Then again, in virtually every country health care system is one of the most knowledge intensive sectors that can significantly boost the socio-economic development of the whole nation. One and possibly the most direct example of the benefits generated by the expansion of the European Union is the potential opportunity for providing cross-border health care services to the citizens of neighbouring countries.

The broader areas of natural sciences and health care have traditionally been among the strongest advantages in Europe, but are not so anymore. Europe is still the world leader in the manufacture of pharmaceuticals, but innovative leadership of pharmaceutical industry has gradually shifted into the USA. While in 1990-2002 the relevant research and development expenditure grew 5 times in the USA, the same type of expenditure incresed by a mere 2.5 times in Europe.[265]

General conditions of the pharmaceutical industry are further aggravated by the onslaught of cheap generic medications from China, Taiwan and Mexico as well as by the growing market share of illegal counterfeit drugs. While the manufacture of generic drugs is shifting into Asia, traditional research and development intensive pharmaceutical industry is moving into Central and Eastern Europe. Scandinavia, on the other hand, is becoming a hot spot for investments due to its special biotechnology intensive pharmaceutical industry. Estonia's advantages in being a potential host country for investments into pharmaceutical industry are not very remarkable at the moment. Estonia could currently offer relatively favourable conditions only for the manufacture of generic drugs.[266]

Then again, bearing in mind the existing research competences, taking advantage of the Scandianvian biomedical cluster is today maybe the only option that Estonia has for developing within the coming 10-15 years a domestic biotechnology sector, which would truly contribute to local economic development (i.e. actually raise real productivity and wage levels). (Figure 39)

A mere ten years ago bringing a part of pharmaceutical industry into Estonia would have meant an investment in the volume of our whole GDP, which is clearly absurd – all the inhabitants of Estonia taken together would not satisfy the requirements of a third phase clinical test. Yet today there is nothing impossible about this, since the section of pharmaceutical industry does not have to be large at all, and some functions are already moving away from the traditional pharmaceutical industry looking for cheaper and high quality

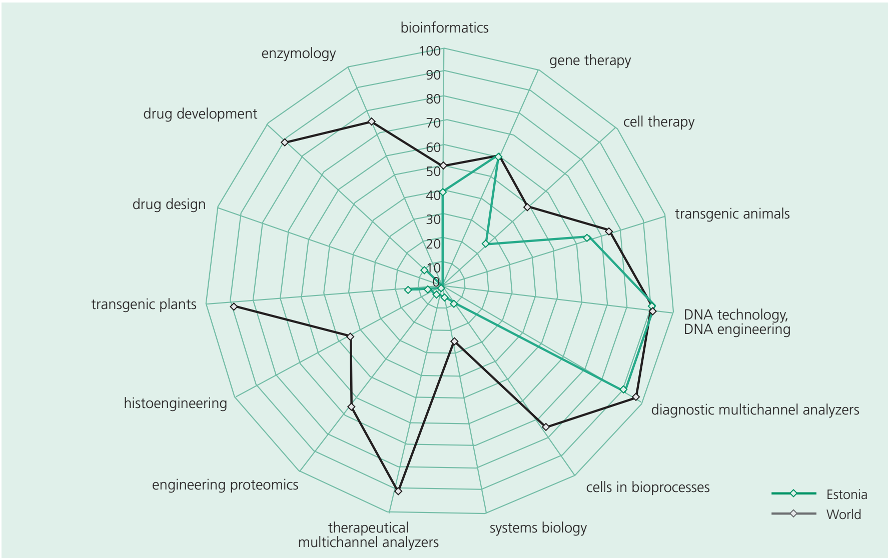
264 See e.g. Tarmo Lemola, "Transformation of Finnish Science and Technology Policy", *Science Studies*, 16, 1, 2003, 52-67; *The future is knowledge and competence, Technology Strategy – review of choices*, Tekes, 2002.

265 I. Brodie *et al*, *EU Life Sciences – Driving Change in the European Life Sciences Industry*, Gap Gemini Ernst & Young, Utrecht 2004, 10; see also Rainer Nitsche, Tom Wilsdon, *Innovation in the pharmaceutical sector*, Charles River Associates, 8th November 2004.

266 I. Brodie *et al*, *EU Enlargement – Driving Change in the European Life Sciences Industry*, Gap Gemini Ernst & Young, Utrecht 2004, 54-62, http://www.de.capgemini.com/servlet/PB/show/1303401/EU_Life_Sciences.pdf;
About biotechnology related developments in Finland and Sweden see also Gabriela von Blankenfeld-Enkvist *et al*, *OECD Case Study on Innovation: The Finnish Biotechnology Innovation System*, Innomarket, Turku, January 2004; Anna Nilsson *et al*, *Knowledge Production and Knowledge Flows in the Swedish Biotechnology Innovation System*, Centre for Medical Innovations, Karolina Institutet, http://www.ki.se/cmi/publications/KnowledgeProductionandKnowledgeFlows.pdf.

labour in the biotechnology sector. The greatest challenge for Estonian policy makers is to make sure that the development of biomedicine does not occur in separation from the trends in the existing industry and knowledge base.

Figure 39. **Biotechnologies' readiness for commercial application; Estonia's strengths and weaknesses.**[267]



Source: the autors.

Even though majority of the biotechnology related discussions often focus on biomedicine and the development of pharmaceutical industry, which both also happen to be the strongest areas of specialisation in Estonia's neighbouring countries, it would be a serious mistake to tie all our future prospects with this area alone.

4.5. Scenario III: Venturing into new high technology economic sectors

Diffusion of knowledge and technology, and rapid technological development of Asian countries force USA as well as Western Europe to invest into radically new technology areas in order to sustain their relatively higher standards of living. Along the lines of what was described in Chapter 2, these technologies will most likely be bio- and nanotechnology.

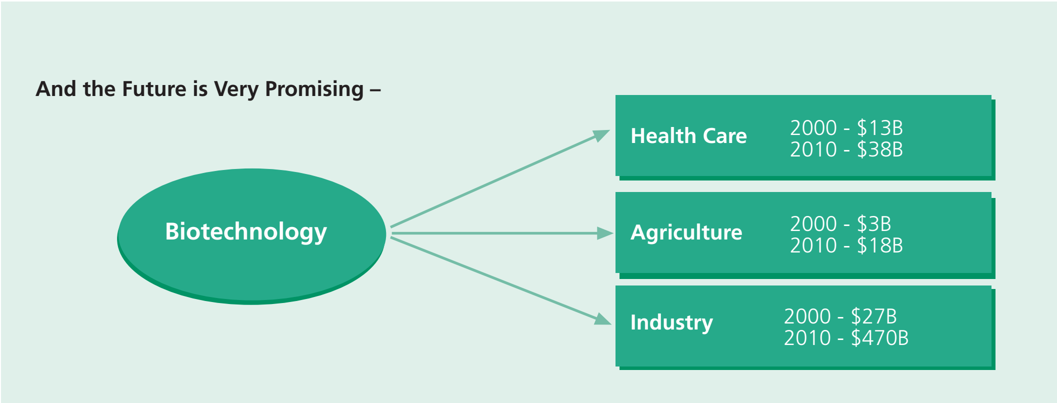
On the one hand, technological development and increasing specialisation help to enhance the effectiveness of current economic activities, but on the other hand, these developments also generate completely new capital goods and markets. Just like the information technology paradigm brought along personal computers, internet and many other previously unimaginable novel products and services and the infrastructure needed to operate them, similar developments can be expected in connection with bio- and nanotechnologies. Unfortunately

[267] This figure is constructed using the information about Estonian biotechnology sector competence base as it was outlined in the study conducted by Fraunhofer ISI in the autumn of 2002. While compiling this book we collaborated with various biotechnology-focused interest groups trying to assess the position of these competences on the technology development curve, and comparing Estonian competences to those in the rest of the world. This figure therefore reflects primarily the opinions of biotechnology experts thermselves about the existing competences and relative position in global competition. See also Fraunhofer ISI, *Research on the Estonian Biotechnology Sector Innovation System*, Tallinn: Enterprise Estonia, 2003, http://www.isi.fhg.de/publ/downloads/isi03b59/estonian-biotechnology.pdf.

we simply do not know yet what those radically new products will look like, what kind of knowledge or skills exactly is needed to generate them or what kind of competitive advantages and specialisation they will engender for Estonia in the longer term and in regard to global scale.

The market share of biotechnology alone is expected to exceed the 100 billion euro threshold by the year 2005. By the end of the decade, the global market share of biotechnology and its related sectors will most likely reach beyond 2000 billion euros.[268]

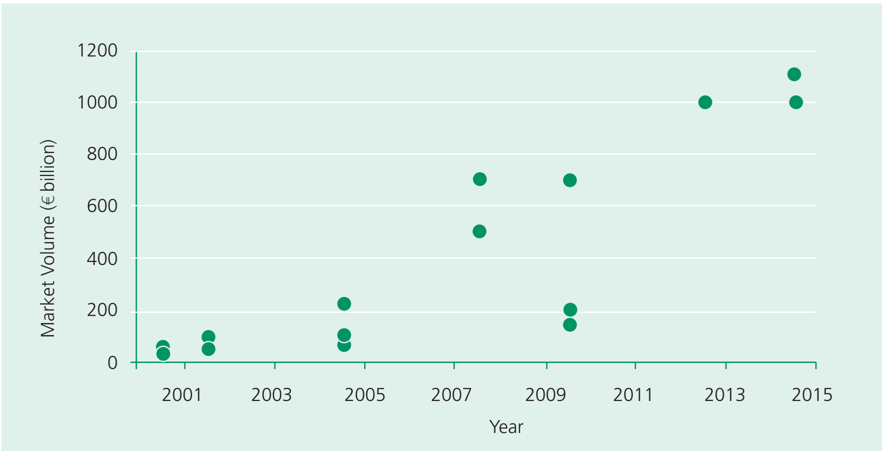
Figure 40. **Assessments of growth in biotechnology market volume.**



Source: McKinsey & Company and Piper Jaffray Ventures

Likewise, the European Commission stands by the estimates of the US National Science Foundation (NSF), *US Nanobusiness Alliance* and many other analysts in believing that the global market for nanotechnology and nanotechnology-based products will grow into the volume of more than a trillion euros by the year 2015.[269] (Figure 41)

Figure 41. **Expected growth of nanotechnology market.**



Source: *Towards a European strategy for nanotechnology*, European Commission, COM(2004) 338 final, 12.5.2004.

[268] *Life sciences and biotechnology — A strategy for Europe*, Communication from the Commission to the European Parliament, the Council, the Economic and Social Committee and the Committee of the Regions, European Commission, 2002, 12. See also *Emerging Biotechnology Players. From Innovation to Realization*, Datamonitor, 2002.

[269] It is important to note that a comparison of the projections various institutions present for nanotechnology market shows that the projections originating from the US tend to be considerably more optimistic than those coming from Europe or Japan. This is well in line with the remarkable gap between the per capita nanotechnology investments in USA and other coutnries. (Table 3, Ch. 2.4).

Explosive growth in research and development investments in the areas of bio- and nanotechnololgy will ensure that the following 10-20 years are going to witness the formation of new dominant technology platforms, emergence of new "winner takes all" markets, and extremely tough technological competition. This kind of investment into new base technologies is somewhat similar to a casino where participating governments and large corporations are forced to make billions of euros, dollars or yens worth of bets, while the rules and other participants of the game will become known only much later when the game is already in full swing.[270]

One option for the smaller countries is to invest in the areas that have been neglected by the large countries for one or another reason. The government of the city-state of Singapore has therefore established a 600 million dollar biotechnology investment fund that focuses primarily on stem cells related research and other state-of-the-art areas in biotechnology. And Singapore is not at all alone in trying to benefit from the standpoint of the US federal government that has banned stem cells related biotechnology research. In addition to Australia, China, India, Japan, Korea and other countries, Arnold Schwarzenegger in the US state of California has personally decided to invest billions of dollars over the coming decade into stem cells research related biotechnology.[271]

Comparable long term and massive investments into basic research, which might potentially generate successful spin-offs that lay the foundations for the emergence of a high technology industry, are virtually impracticable in Estonian circumstances. The actual volume of investments needed and the related risks are simply too large. Yet the Irish experience in the 1980-1990s shows Estonia that an active and well-focused policy of attracting appropriate foreign investments can help us partake in this.[272] Ireland has managed to successfully exploit its membership of the European Union to attract high technology investments from USA. In the light of good logistics, labour supply, cultural proximity and other favourable conditions, the goal of American industrialists in making massive investments in Ireland was really nothing less and nothing more than to establish a production base for entering the European market. Since the US investments helped Ireland enter the new emerging industry sectors significantly earlier and more forcefully than most of the other European Union member states did, it accelerated considerably the development of the whole economy and society as the economy went through fairly drastic structural changes.[273]

Today's Finland is a good example of a country where one of the primary motivations for the incoming foreign direct investments is the presence of specific competences and the strong economic clusters surrounding them. Availability of prior world-class research and development is of vital importance when trying to attract such investments.[274]

Developing countries like Estonia are better off attracting investments that are looking to occupy new markets just like it happened in Ireland. At the same time, the countries should make sure that these transactions bring along not only production, but also some research and development related activities. Even if Estonia does not have as many logistic, cultural and other advantages as Ireland does for obtaining investments from the US, it should still explore very seriously various opportunities for encouraging bio- and nanotechnology related investments from USA, South East Asia and other regions. The Irish experience has demonstrated that a deep understanding of the emergence and formation processes of new industry sectors in USA, Asia and elsewhere is a critical precondition to the success of this policy, as is a proactive attitude in approaching

270 See Brian W. Arthur, "Increasing Returns and the New World of Business", *Harvard Business Review*, July-August 1996, 100-109.

271 Bruce Einhorn, Jennifer Veale, Manjeet Kripalani, "Asia is stem cell central", *BusinessWeek*, 15.01.2005; "Schwarzenegger in stem cell research", *BBC News*, 19.10.2004.

272 About the analysis of the choice of location for foreign investments and investment decisions see John H. Dunning, „The eclectic paradigm as an envelope for economic and business theories of MNE activity", *International Business Review*, 9, 2000, 163-190.

273 As a reminder, before Ireland joined the European Union, most of its incoming investments were of the market-seeking type as well, especially since they mostly came from the United Kingdom and Continental Europe rather than the US. See Frank Barry, Aoife Hannan, *Will Enlargement Threaten Ireland's FDI Inflows?*, Quarterly Economic Commentary, Economic and Social Research Institute, Dublin, December 2001, 55-67, 60; „Investment in Finland reaches a market of 80 million people", *EnterpriseFinland*, 31.3.2004.

274 On this point see also Cees van Beers, *The Role of Foreign Direct Investments on Small Countries' Competitive and Technological Position*, Government Institute for Economic Research, Helsinki, 2003, 116, http://extranet.vatt.fi/knogg/Reports/t100.pdf.

specific companies and offering them favourable conditions to launch production in Europe.

There are, of course, no ready-made criteria for predicting the growth of emerging industries, but a comparison of some general indicators like total volume of investment into research and development as well as risk financing figures, publication and patenting data etc can serve as a fairly good guide to sectoral advances.[275] Table 16 lists, for instance, leading institutions in nanotechnology patenting. Once again we see mostly US companies and research institutions in the lead. USA and IBM as a country and as a company, respectively, also outrank everyone else in the comparison of patent citations, i.e. both US and IBM patents are cited most often in the world.[276]

Table 16. **Top 20 institutions that have registered the highest number of nanotechnology related patents in the US Patent Office during the years 1976-2002.**

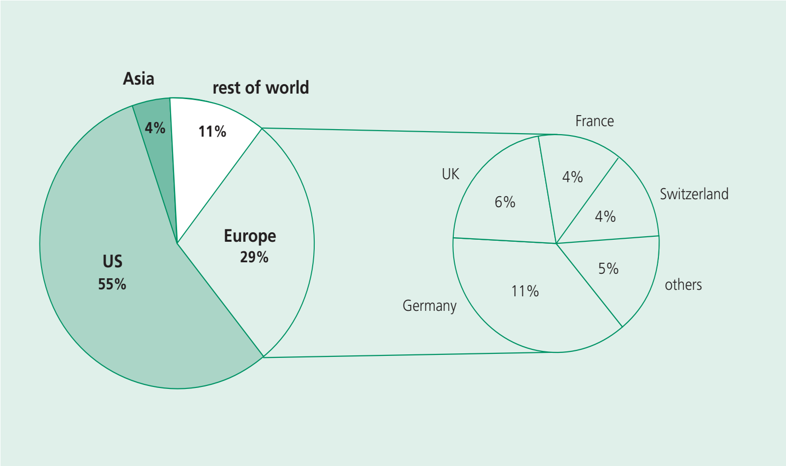
Rank	Assignee Name	Number of Patents	Average Patent Age
1	International Business Machines Corporation	1302	6.74
2	Xerox Corporation	957	7.55
3	Minnesota Mining and Manufacturing Company	807	7.69
4	Eastman Kodak Company	708	10.38
5	Motorola, Inc.	508	7.16
6	The Regents of the University of California	491	4.13
7	NEC Corporation	483	4.42
8	Micron Technology. Inc.	457	2.53
9	Canon KaDushiki Kaisha	408	5.52
10	E. I. Du Pont de Nemours and Company	367	11.45
11	General Electric Company	367	11.54
12	Texas Instruments Incorporated	366	7.77
13	Hitachi. Ltd.	335	6.43
14	The United States of America as represented by the Secretary of the Navy	330	8.63
15	The Dew Chemical Company	327	11.04
16	Kabushiki Kaisha Toshiba	317	5.47
17	Abbott Laboratories	297	6.62
18	Advanced Micro Devices. Inc	295	2.61
19	Massachusetts Institute of Technology	271	8.28
20	Merck & Co., Inc.	251	8.63
	Average	482.2	7.23

Source: Huang et al., „International nanotechnology development in 2003: Country, institution, and technology field analysis based on UPTSO patent database“, *Journal of Nanoparticle Research*, 6, 2004, 325-354, 336.

275 Patent statistics and the like are not really all-powerful. It should be kept in mind when analysing different technology areas that competitive positions as well as diverse strategies companies use for market entry in different sectors vary significantly between the areas. Statistics itself is characterised by certain innate inertia and resistance to changing classifications etc, which usually results in the emerging industries being ignored until they are so big and important that they simply cannot be ignored anymore. This is what inspired the famous quote by Robert Solow in the 1980s: „computers are everywhere but productivity statistics”.

276 Huang *et al.*, „International nanotechnology development in 2003: Country, institution, and technology field analysis based on UPTSO patent database“, *Journal of Nanoparticle Research*, 6, 2004, 325-354, 345-346.

Figure 42. **New nanotechnology companies established in 1997-2002.**



Source: CEA, Bureau d'Etude Marketing.

Estonia's competence base in new key technologies is actually in a pretty good shape, and that is due to historic reasons.[277] On the one hand, Estonia does lag significantly behind Scandinavia in bio- and nanotechnology, neurosciences and immunology in regard to the number of scientific publications per inhabitant, but then again, Estonian numbers compare rather well with those of Ireland. (Table 17)

Table 17. **Scientific publications and citations per million inhabitants.**

	Bio-informatics		Genetics		Nano-technology		Neurosciences		Immunology	
	Publ.	Cit.	Publ.	Cit.	Publ.	Cit.	Publ.	Cit.	Publ.	Cit.
Estonia	**17.0**	**67.4**	**129.9**	**341.5**	**44.7**	**104.4**	**217.2**	**592.1**	**186.0**	**472.8**
Latvia	3.0	0.4	17.5	28.1	23.8	15.3	35.8	53.2	49.0	120.5
Lithuania	3.1	11.4	22.0	113.3	28.1	24.2	34.8	67.4	33.1	60.4
Finland	80.1	279.7	1153.2	5651.2	148.3	295.7	1417.3	3963.2	1745.2	5506.3
Sweden	115.8	440.4	965.3	4240.8	296.3	720.7	1611.6	4565.8	2148.4	7398.1
Denmark	94.7	406.2	868.6	3482.7	191.7	726.2	1083.5	2825.2	1507.7	5093.1
Iceland	117.5	110.4	1421.0	8799.9	60.5	138.9	609.0	1299.9	901.0	2706.6
Ireland	27.5	87.4	270.4	1103.4	94.3	246.9	462.0	1188.3	539.0	1713.0
Poland	5.6	7.6	49.9	85.2	33.1	23.2	105.2	105.7	92.7	131.2

Source: Mapping excellence in Science and Technology across Europe, http://www.cwts.nl/ec-coe, December 2003.

Up until very recently, however, Ireland also paid relatively little attention to independent research and development policy. In order to rectify this situation and alleviate the shortage of top specialists, Ireland has recently embarked on proactive policies to attract the researchers and engineers from all over the world to

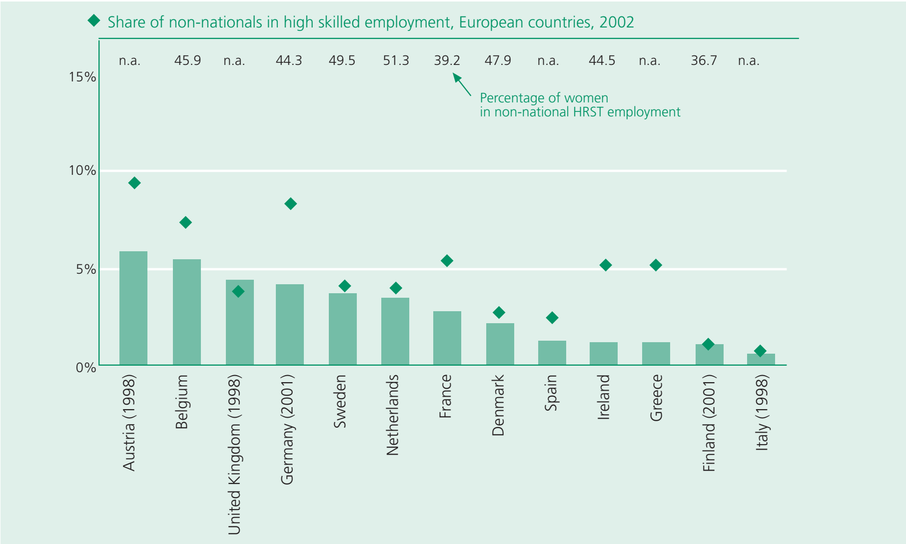
[277] While Estonian competence base in biotechnology has been well mapped in the Fraunhofer study, in the case of nanotechnology, on the other hand, it is not even clear what the competence base in Estonia looks like, and how much are the companies that today dominate Estonian economy able to utilise nanotechnology. In all probability, this capacity is very moderate.

[278] See e.g. Science Foundation Ireland, http://www.sfi.ie.

come to Ireland where they are badly needed in the fields of information and biotechnology.[278]

Likewise, Estonia needs to considerably expand its bio- and nanotechnology competence base so as to keep pace with other countries. Whereas Ireland has a much better demographic profile (Figure 32 in Ch. 3.4), Estonian society might be much more willing than Western Europe or even the Nordic countries to accept students from Asia, and thereby create an important long-term competitive advantage. Being a small country in Europe, this kind of internationalisation seems pretty much inevitable. (Figure 43)

Figure 43. **Share of foreign workers in highly skilled European workforce, 2002.**



Source: *OECD Science and Innovation Policy: Key Challenges and Opportunities*, 2004, 37, http://www.oecd.org/dataoecd/18/17/23706075.pdf.

Creating a cutting edge competence base in bio- and nanotechnology requires not only significant diversification in the supply of education,[279] but also a considerably more active and clear-cut government support specifically to bio- and nanotechnology related basic research and technology development. This all is useful when there is a very sound system of intellectual property protection in place, which, in turn, also ensures a more effective protection of the research results published in academic journals etc.

Since in Europe private sector investments into research and development are strongly clustered both sector-wise and within specific industries, local research and development activities can occur only with the involvement of the foreign owners of companies. It is therefore crucial for Estonia to look for opportunities to more actively engage in the research and development programmes of the Nordic countries and Europe as well as in the more fitting European technology platforms now being launched.[280]

At the same time, developing countries like Estonia should be careful about the investment-based development path, because successful development in one specific sector (bio- or nanotechnology, for instance) might not automatically translate into a considerable positive impact on the well-being of Estonian population. The latter may happen when, for example, the new high technology sector will emerge as a small part of a larger international production network that does not have much business with traditional economy, and where all the added value generated will move out of Estonia. This means that simultaneously with strengthening the competence base in bio- and nanotechnology, Estonia must also modernise its existing industry, especially the sectors that yield more employment and export volumes in Estonia like forest, food, textile and chemical industry etc.

[279] Since nanotechnology raises questions about the adequacy of the whole current division between different research fields, various opportunities should be explored in Estonia for changing the way science and engineering classes are taught, starting with high school level education.

[280] In most of the European countries 20-30 largest companies basically account for the majority of industrial research and development investments. See *Monitoring industrial research: the 2004 EU industrial R&D scoreboard, volume I*, European Commission, 2004, http://eu-IRIscoreboard.jrc.es/; For details about European technology platforms see http://www.cordis.lu/technology-platforms/.

5. Policy recommendations

By no means does the analysis presented above claim to provide the absolute prophesy about the upcoming developments in the next decade. Moreover, it is highly unlikely that any of the described scenarios would materialise automatically in the exact way depicted above; it would sooner be some combination of them. Predicting the future is not the actual goal in the process of envisaging potential long-term development trends. The value of this work lies rather in outlining the premises, relevant risks and windows of opportunity that these strategies entail.

Even if chance does play a fair share in this all, the investment opportunities for entrepreneurs as well as further development of Estonia as a whole will mostly depend on the activities that the public sector decides to embark on (or not to embark on) in shaping Estonian economic environment. Without a clear long-term vision, however, these activities have no chance of success.[281]

Although the *Lisbon strategy* of the European Union and *Knowledge-based Estonia* have both been instrumental strategic documents in raising the issue of economic competitiveness into the focus of political agenda, Estonia today still lacks the mechanisms to ensure that Estonian economy is actually moving towards higher knowledge intensity. Since regular assessment of policies and their impact is not yet common practice in many areas essential to the competitiveness of Estonian economy, then public policy is also visibly uneven having no obvious goal and incapable of solving the structural problems facing our socio-economic development.[282]

So for instance, Estonian innovation policy does not currently provide any effective mechanisms to influence the factors that hinder productivity growth in wood processing or electronics industries, which have greatest impact on our economic growth and exports. Neither are there any schemes that would specifically support the emergence of new high technology economic sectors. The needs of the companies in those two industries are, however, radically different.

Since the mechanisms for public policy development and coordination are generally extremely weak, then education, research and development, employment, innovation and other policies also have a mere marginal impact within the current framework.

5.1. Cluster-based economic policy

One of the primary tasks for Estonian public sector is basically to answer the following question: how to ensure a systematic consideration of private sector problems in public policy development and assessment. In order to do that the government needs a system that provides it with constant feedback on the actual trends in private sector as well as potential long-term developments, labour needs etc. Establishing such a system is one of the major prerequisites for the creation of any kind of comprehensive long-term development strategy in Estonia. This system for policy development and coordination should prioritise the goals of social and environmental sectors along with the 5-6 most important economic clusters in regard to technological and socio-economic development (for example, wood and forestry cluster or information technology and electronics cluster etc), the value chains of which together basically account for the whole Estonian economy.

Establishing this system in practice entails the formation of permanent task forces comprising representatives from private and public sectors. These groups then generate regular overviews of potential future developments, current problems and possible solutions in their sector. Reports presented by these task forces must then become an integral part in the process of education, research and development policy formulation, coordination and evaluation.

[281] Carlota Pérez, „Technological change and opportunities for development as a moving target", *CEPAL Review 75*, December 2001, 109-130.

[282] See *Riigi tegevus raha suunamisel ettevõtluse toetamiseks* [Government activities in providing funding for entrepreneurship development], Audit Report No 2-5/03/95, State Audit Office of Estonia, 2003; *Outcome of the product develeopment projects supported by the Enterprise Estonia Foundation*, Audit Report No 2-5/04/109, State Audit Office of Estonia, 2004.

The primary output of the above task forces should be formulation of technology programmes needed for the development of the respective clusters, their later assessment and constant updating. The issues presented in these programmes must reach the whole policy spectrum from new curricula formation to the schemes for attracting foreign investments and export subsidies. They would then a) actually create new sectors where Estonia emerges with strong research and development, which is well competitive on the European scale; which are also b) closely related to real economic activities; c) interdisciplinary and d) grounded in the collaborative efforts of local as well as foreign (if needed) competence centres.

5.2. More effective policy coordination in the Baltic Sea region

In the ever tightening global economic competition, Estonia is clearly an integral part of the economic area of the Baltic Sea region and of the surrounding cross-border economic clusters. Any long-term development strategy Estonia adopts therefore needs to take into account the development plans of our neighbouring countries and include mechanisms for the coordinate our long-term policies (incl. education, research etc).

Nordic countries have long understood that small states are not necessarily competitors in the global competition. Instead, they can fairly successfully complement each others' competitive advantages. Having became a part of the economic clusters of the Baltic Sea region rather organically and effortlessly, it will be a major challenge for Estonia to significantly improve the coordination of its education, research, innovation and other policies with those of the Nordic countries as well as Latvia and Lithuania.

Initiating international foresight and cluster programmes the prospective goals or which is to support advanced specialisations in higher education, and open up national research and development programmes to each other is undoubtedly one of the softer forms of policy coordination.

5.3. Developing infrastructure for knowledge and technology

Although governments around the globe often have the tendency to think of infrastructure development in a static form of roads and sewage treatment facilities, nearly every single one of such projects also entails an opportunity for technology development. Investment in power plants or public transportation and the like can be used to offer domestic companies a good occasion for learning and enhancing their competitive advantages. Public procurement system must support the exploitation of such opportunities.

In addition to better policy coordination and initiation of cluster-based technology programmes Estonian public policy should continuously pursue the following three key targets:

1. Attracting talented people to come and work in Estonia, and providing them with a favourable working and living environment;
2. Facilitating knowledge and technology transfer from foreign investment based enterprises into domestic industries and service sectors;
3. Increasing the capability of local enterprises to apply the knowledge created abroad, including continued education and in-service training; investing in basic research to keep abreast of global research and technology trends and to sustain the high quality of our educational system.

6. Appendices

Table 18. **Supply and demand of industrial produce in Estonia (in current prices).**

	Apparent consumption[283]							
	Total (US$ '000)	Per-capita (US$)	Ratio of output to apparent consumption		Imports as % of apparent consumption		Exports as % of output	
Industry (ISIC 4-digit code)	2000	2000	1997	2000	1997	2000	1997	2000
Processing/preserving of meat (1511)	110897	80	0.72	0.80	65.10	46.60	51.50	33.00
Processing/preserving of fish (1512)	**42580**	**31**	**1.37**	**2.10**	**34.50**	**52.40**	**52.10**	**77.30**
Processing/preserving of fruit & vegetables (1513)	35311	25	0.54	0.31	66.00	86.30	37.50	55.90
Dairy products (1520)	**122276**	**88**	**1.18**	**1.23**	**40.10**	**23.80**	**49.10**	**38.00**
Grain mill products (1531)	16253	12	0.30	0.19	96.20	85.80	87.30	24.60
Starches and starch products (1532)	...	...	-	...	99.00	...	87.60	...
Prepared animal feeds (1533)	25383	18	0.70	0.56	31.90	45.50	2.90	2.30
Bakery products (1541)	66071	47	0.85	0.90	21.20	11.70	6.80	1.90
Cocoa, chocolate and sugar confectionery (1543)	36281	26	...	0.56	...	89.60	...	81.30
Other food products n.e.c. (1549)	...	...	0.44	...	87.10	...	71.00	...
Distilling, rectifying & blending of spirits (1551)	39655	28	0.76	0.73	29.30	41.70	6.60	20.60
Wines (1552)	26226	19	0.11	0.29	90.10	73.20	12.90	6.10
Malt liquors and malt (1553)	53338	38	0.85	0.93	22.30	20.00	8.50	13.70
Soft drinks; mineral waters (1554)	**25492**	**18**	**1.01**	**1.00**	**33.00**	**31.20**	**33.60**	**31.30**
Textile fibre preparation; textile weaving (1711)	134301	96	0.77	0.74	87.10	88.20	83.10	84.10
Carpets and rugs (1722)	**16947**	**12**	**0.76**	**1.08**	**39.50**	**25.50**	**20.00**	**30.90**
Tanning and dressing of leather (1911)	16072	12	0.39	0.19	93.40	90.10	82.90	49.00
Luggage, handbags, etc.; saddlery & harness (1912)	6705	5	...	0.68	...	91.60	...	87.60
Sawmilling and planning of wood (2010)	**60945**	**44**	**...**	**3.47**	**...**	**38.10**	**...**	**82.20**
Builders' carpentry and joinery (2022)	**68854**	**49**	**1.03**	**1.28**	**14.30**	**13.10**	**16.90**	**32.20**
Other wood products; articles of cork/straw (2029)	**8591**	**6**	**3.23**	**2.04**	**36.70**	**31.30**	**80.40**	**66.40**
Corrugated paper and paperboard (2102)	27513	20	0.53	0.60	64.40	60.60	33.20	34.50
Other articles of paper and paperboard (2109)	56829	41	...	0.34	...	89.70	...	70.00
Publishing of books and other publications (2211)	30441	22	0.60	0.60	48.10	44.80	13.40	8.10

Publishing of newspapers, journals, etc. (2212)	**47448**	**34**	**0.97**	**1.02**	**4.70**	**3.60**	**1.70**	**5.70**
Other publishing (2219)	7787	6	0.61	0.89	40.90	19.40	3.40	9.80
Printing (2221)	56002	40	0.89	0.94	25.10	22.40	16.00	17.30
Service activities related to printing (2222)	3986	3	0.78	0.96	25.80	14.10	5.40	10.60
Processing of nuclear fuel (2330)	...	...	0.00	...	100.00	...	...	...
Other chemical products n.e.c. (2429)	74814	54	0.63	0.48	47.40	65.80	17.10	29.20
Plastic products (2520)	155999	112	0.46	0.48	75.00	80.50	45.90	59.80
Glass and glass products (2610)	43361	31	0.96	0.90	79.50	68.00	78.50	64.50
Refractory ceramic products (2692)	...	...	0.67	...	33.90	...	1.60	...
Struct.non-refractory clay; ceramic products (2693)	18776	13	0.26	0.65	84.20	46.40	40.30	17.80
Cement, lime and plaster (2694)	**11878**	**9**	**2.04**	**1.72**	**16.70**	**18.00**	**59.30**	**52.40**
Articles of concrete, cement and plaster (2695)	49877	36	0.91	0.97	27.00	20.00	20.20	17.70
Cutting, shaping & finishing of stone (2696)	7005	5	0.83	0.87	23.70	18.70	7.90	7.10
Other non-metallic mineral products n.e.c. (2699)	19424	14	...	0.36	...	87.70	...	65.70
Tanks, reservoirs and containers of metal (2812)	...	...	0.37	...	95.30	...	87.40	...
Cutlery, hand tools and general hardware (2893)	26440	19	0.36	0.43	88.40	84.10	68.20	62.60
Other fabricated metal products n.e.c. (2899)	104098	75	0.43	0.43	82.00	85.60	57.80	66.70
Ovens, furnaces and furnace burners (2914)	...	...	0.65	...	82.60	...	73.20	...
Other general purpose machinery (2919)	73498	53	...	0.41	...	77.90	...	46.30
Agricultural and forestry machinery (2921)	31344	23	0.32	0.50	89.70	73.70	68.00	47.70
Food/beverage/tobacco processing machinery (2925)	16080	12	...	0.39	...	69.60	...	22.50
Electricity distribution & control apparatus (3120)	...	...	0.54	...	62.70	...	31.00	...
Electronic valves, tubes, etc. (3210)	485763	349	0.12	-	92.30	97.30	37.50	55.20
Industrial process control equipment (3313)	48423	35	0.78	0.96	50.60	5.40	36.50	1.40
Building and repairing of ships (3511)	53587	38	0.92	0.88	20.60	18.50	13.40	7.80
Building/repairing of pleasure/sport. boats (3512)	...	...	0.77	...	85.30	...	80.90	...
Furniture (3610)	**97973**	**70**	**1.32**	**1.78**	**35.30**	**42.10**	**51.00**	**67.50**
Jewellery and related articles (3691)	5083	4	0.83	0.80	69.80	76.20	63.60	70.30
Musical instruments (3692)	**...**	**...**	**1.10**	**...**	**83.70**	**...**	**85.10**	**...**
Other manufacturing n.e.c. (3699)	29489	21	0.43	0.56	81.60	77.70	56.80	60.00

Source: United Nations Industrial Development Organisation, June, 2004, http://www.unido.org/.

[283] Apparent consumption is defined as output plus imports less exports.