University of Tartu
Faculty of Social Sciences
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The Role of Innovation Policy in an Industrial Catching-up Strategy for Estonia

Thesis in partial fulfilment of the requirements for the
Master of Arts in Public Administration and Social Policy Degree

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Table of Contents

Abstract

In this thesis, an analysis of the competitiveness and future outlooks of the Estonian economy is carried out. The above research builds on evolutionary theories of innovation and socio-economic development, developed by Joseph Schumpeter, Christopher Freeman, Michael Porter, Carlota Perez, and various international studies.

The author concludes that despite seemingly favourable developments in Estonia over the last ten years, the share of medium and high-tech branches has declined both in Estonian manufacturing value added and in exports. Furthermore, over the last years, the growth of average salaries in Estonia has outperformed the productivity gains while the current account deficit and external debt have expanded significantly. Thereby competitiveness of the Estonian economy has deteriorated.

Despite Estonia's successful compliance with the *Copenhagen criteria,* European Union membership, the adoption of the *acquis communitaire* and joining the *single market*, an increase of welfare will by no means be automatic. To catch up with more developed Western economies, a huge amount of work still lies ahead of Estonia in improving her competitiveness and meeting her mounting social and economic challenges.

On this basis, in the context of the European Union *Lisbon Strategy*, three mini-scenarios with possible policy approaches to Estonia's future international specialisation are outlined. Yet, none of these scenarios embody self-fulfilling prophecies. Rapid growth involves strong political leadership and visionary well co-ordinated structural changes in the development of human resources, production capabilities and social capital.

Lühikokkuvõte

Käesolev magistritöö analüüsib Eesti majanduse konkurentsivõimet ja tulevikuväljavaateid. Uurimistöö tugineb Joseph Schumpeteri, Christopher Freemani, Michael Porteri, Carlota Perezi jt arendatud innovatsiooni ning sotsiaal-majandusliku arengu evolutsioonilistele käsitlustele ning erinevatele rahvusvahelistele uuringutele.

Autor leiab, et vaatamata Eestis viimase kümne aasta jooksul aset leidnud esmapilgul soodsatele arengutele, on keskmise- ja kõrgtehnoloogiliste tegevusalade osakaal langenud nii tööstuse toodetud lisandväärtuses kui ekspordis. Lisaks on keskmise palga kasv Eestis osutunud viimastel aastatel tootlikkuse kasvust kiiremaks, märkimisväärselt on suurenenud jooksevkonto defitsiit ja välisvõlg. Eesti majanduse konkurentsivõime langenud.

Vaatamata edukale Euroopa Liidu *Kopenhaageni kriteeriumite* täitmisele, *acquis communitaire*'i omaks võtmisele ja Euroopa Liidu liikmelisusele ei ole Eesti tulevane heaolu kasv automaatselt tagatud. Arenenud lääneriikidele järele jõudmiseks seisab Eesti konkurentsivõime tõstmisel ning eesseisvatele sotsiaal-majanduslikele väljakutsetele vastamisel ees väga mahukas töö.

Seetõttu pakutakse töös Euroopa Liidu *Lissaboni strateegia* kontekstis välja kolm võimalikku mini-stsenaariumit erinevate lähenemistega Eesti tulevase rahvusvahelise spetsialiseerumise arendamiseks. Ühtki neist stsenaariumitest ei tohiks siiski võtta iseeneslikult täidemineva ennustusena. Kiire areng eeldab tugevat poliitilist eestvedamist ning üheaegseid hästi koordineeritud struktuurseid muutusi nii inimressursi, tootmisbaasi kui sotsiaalse kapitali arendamisel.

Acknowledgements

I would like to express my gratitude to my supervisor, Professor Dr. Wolfgang Drechsler, who helped me enormously in acquainting myself with both classical and modern leading points of view in economics and public administration on the foundations of socio-economic development.

Also, I'm deeply indebted for the opportunity to come in close working contact with Dr. Carlota Perez, Dr. Erik S. Reinert and the team of the Other Canon economists, to all of whom I'm particularly grateful for their specific comments and suggestions on the report on the competitiveness of the Estonian economy.

Sir Josiah Charles Stamp, one of the pioneers of British philosophy of administration once said: *"It is rightly stated that the training of the scientist includes no awareness of the social consequences of his work, and the training of the statesman and administrator no preparation for the potentiality of rapid scientific advance and drastic adjustment due to it, 'no prevision of the technical forces which are shaping the society in which he lives'. The crucial impact is nobody's business."*

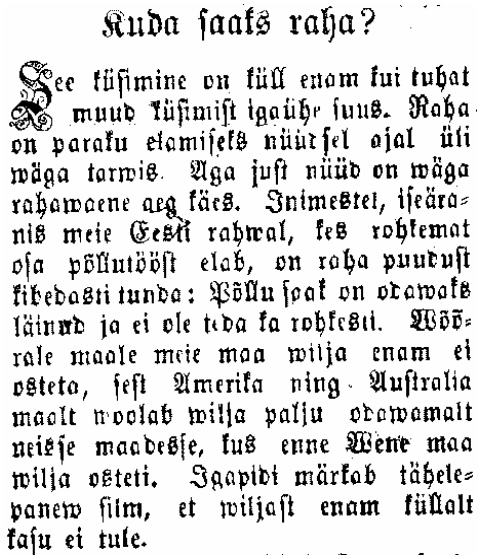
I am very grateful to the Department of Public Administration of the University of Tartu, that has provided me with education, which Stamp would have found in every aspect to be of highest standards.

A great big special thanks to my close colleagues and superb friends Dr. Rein Kaarli, Mr. Tarmo Kalvet, Prof. Dr. Rainer Kattel, Mr. Tarmo Pihl, Mr. Silver Toomla, Mr. Rene Tõnnisson for their encouragement and devotion to common research interests.

In the context of my professional work for the Estonian Research and Development Council, I would like to thank Mr. Siim Kallas, Prime Minister of Estonia in 2002-2003, currently Commissioner of the European Commission, for providing stimuli and an encouraging working environment, while leaving me time for analytical work to explore Estonia's prospective medium- to long-term futures and development outlooks.

The current research was also supported by European Commission Directorate General Research. As part of foresight pilots run in Estonia by *e*Foresee project, several workshops and seminars were organised with the participation of representatives of industry, universities and ministries. In this process highly useful ideas, feedback and suggestions were collected. I am deeply grateful to those who joined in the process and made it through their contributions a fascinating brainwork.

Part I



Kuda saaks raha?

See küsimine on küll enam kui tuhat muud küsimist igaühe suus. Raha on paraku elamiseks nüüdsel ajal üli wäga tarwis. Aga just nüüd on wäga rahawaene aeg käes. Inimestel, iseäranis meie Eesti rahwal, kes rohkemat osa põllutööst elab, on raha puudust kibedasti tunda: Põllu saak on odawaks läinud ja ei ole teda ka rohkesti. Wõõrale maale meie maa wilja enam ei osteta, sest Amerika ning Australia maalt woolab wilja palju odawamalt neisse maadesse, kus enne Wene maa wilja osteti. Igapidi märkab tähelepanew silm, et wiljast enam küllalt kasu ei tule.

Postimees, 4 December 1886

Industrialisation and catching-up: theoretical foundations, global context and policy options for Estonia

1. From historic legacy to modern theory of economic development

In 1886, Johann Woldemar Jannsen opened the lead article of the newly established weekly *Postimees* with a discussion of the troublesome economic situation in Estonia due to the increasing dominance of the relatively cheaper American and Australian agricultural sales outperforming Russian exports in the world markets. As for prescriptions to the observed deficiencies, Jannsen advocated for greater focus on horse-breeding in combination with a related shift in farming towards a greater supply of provender. (Jannsen 1886)

In comparison to developed nations, Estonia was not an industrialised country at the end of the 19th century. As throughout earlier centuries Baltic countries, like several other parts of Eastern Europe, were predominantly agricultural sub-suppliers for wealthier regions of Europe. (Chirot 1991) Acknowledging this historical context, modern economic thinkers easily recognise in Jannsen's policy advice to farmers, what would be nowadays seen as a call for a shift towards *knowledge based economy*.

Indeed, if re-phrased in modern fashion, essentially Jannsen's article suggested that innovation and the clustering of traditional economic activities with new activites which are increasingly specialised and thereby more knowledge-intensive, improves competitiveness of economy and thereby overall wellbeing of the nation.[1]

In modern theory, socio-economic development is seen as a step-by-step evolutionary process whereby, within an ever-evolving socio-political institutional framework, en-

[1] One of the most straightforward definitions, supplied by the World Economic Forum, is that competitiveness is the ability of a country to achieve sustained high rates of growth in GDP per capita. (WEF 2003) A similar but more detailed definition, supplied by the OECD, is that competitiveness is the degree to which a nation can, under free trade and fair market conditions, produce goods and services which meet the test of international markets, while simultaneously maintaining and expanding the real incomes of its people over the long-term. (OECD 1992)

trepreneurs aiming at competitive advantages continuously endeavour for acquiring new competitive assets and upgrading the existing ones. Thereby, long-run growth is based foremost on technological progress and huge economies of scale stemming from the dominance of high value added markets. (Schumpeter 1936, Romer 1986, Porter 1990, Dosi and Nelson 1994, OECD 1999, OECD 2001, Rodrigues 2002)

Also in the current thesis, and thus directly in-line with the views of Max Weber, Joseph Alois Schumpeter, and Frank Hyneman Knight, entrepreneurial sprit, rationalisation, innovativeness and uncertainty as opposed to calculable risk are acknowledged as primary sources and influences of socio-economic development.[2]

2. Competitiveness of the Estonian economy

Since its independence at the beginning of the 1990s, Estonia has been strongly relying on the currency board system and rigid financial discipline to maintain the stability of currency, and literally a complete deregulation of markets. Estonia's catching-up with the developed industrial countries in terms of welfare and economic growth during the 90s is chiefly associated with the shutdown of uneconomic undertakings, the application of free entrepreneurial initiative, the introduction of modern management skills and the inward technology transfer spurred by foreign direct investments. (Tiits *et al* 2003) As the macroeconomic environment stabilised, the following economic growth seemed to be automatic.[3]

Indeed, overall Estonia has enjoyed seemingly positive developments. The boom of emerging markets brought about by the global economic downturn (Rogoff 2004, Sheperd 2004), the positive sentiment related to the forthcoming European Union enlargement and extraordinarily low interest rates have led Estonia to soaring stock exchange and real estate markets (Arco Vara 2003) and largely domestic consumption based growth (BoE 2004).

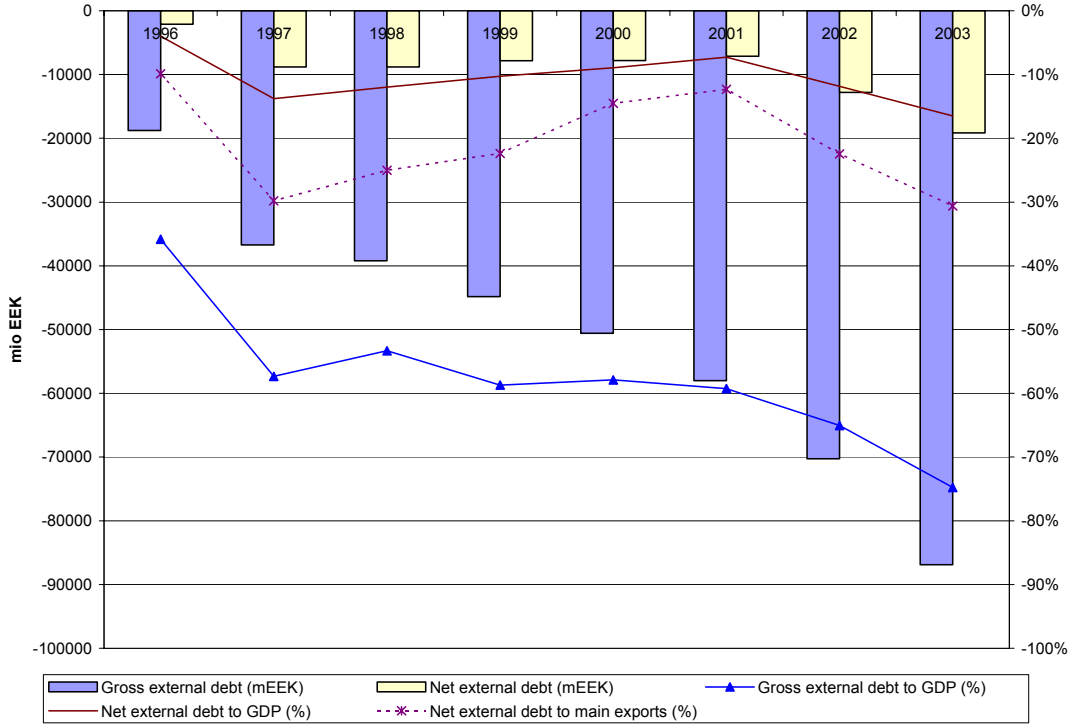
The rapid increase of external debt (Figure 1) and the record high current account deficit of -13.7 % of GDP (BoE 2004) have elevated the risks of possible financial market volatilities.[4] (IMF 2004, 39; Tiits 2003) However, over the last few years the rise of real income has outperformed the increase in productivity (Tiits *et al* 2003, 17) showing that the Estonian economy does not produce enough added value to sustain the current pace of the increase of salaries.

In order to catch up with the core EU, Estonia should be able to significantly expand the value added produced and the volume of its exports. Regrettably, an analysis of the strength of the supply side of the Estonian economy demonstrates the decreasing specialisation (EC 2003a, 229) and the decreasing importance of middle- and high-tech industries in exports as well as in manufacturing value added. Thereby, despite

[2] For a review of the lives of these great thinkers and their mutual influences see: Brouwer 2002.
[3] Despite certain difficulties with the comparability of statistical data of the Soviet Union, Maddison claims that for 1998 Estonia had not yet reclaimed it's 1990 level of GDP per capita. (Maddison 2001, 184)
[4] While near-term vulnerabilities in the EU new member states are according to IMF studies cushioned by adequate international reserves, it may become hard to balance the economy when a solid economic growth in Western Europe is restored and interest rates in *eurozone* start to increase.

the enviable records of economic growth in Estonia in the 1990s the competitiveness of the economy has actually deteriorated. (Tiits *et al* 2003, 26)

Figure 1. Estonia's external debt



Source: BoE 2004, author's calculations.

As fully predicted by theory, and as witnessed by Estonia also in the 1920s (Kõll and Valge 1998, 32-39), the liberalisation of markets *per se* does not guarantee a higher rate of economic growth, increase of competitiveness and welfare. (Prasad *et al* 2003, Stiglitz 2003, UNDP 2003) On the contrary, undue liberalisation can easily lead to a gradual demolishment of indigenous industries starting from the relatively most knowledge intensive ones. (Abramovitz, 1989)

In *The Wealth of the Nations*, Adam Smith has expressed what has become by now classic knowledge: if the economy is to develop and grow, different institutional mechanisms are to be implemented in different stages of the economic development. Smith also formulated the gravest mistake that can be made in the development of the economy *i.e.* the introduction of policies that do not correspond to the level of development. (Smith 1776, Book 4, II, 399 *cited in* Reinert 1999)

A stable macro-economic environment is a vital precondition for economic development. Nonetheless, one must not forget that welfare and added value emerge at the micro-economic level, depending on the ability of companies to produce high value added products and services efficiently. The key of sustainable and stable economic development lies in the balance of micro- and macroeconomic environment – it is necessary to monitor and direct each of them. It is not sufficient to draw attention only to the supply side of economy or focus exclusively on macroeconomic indicators, believing that all the rest will develop automatically in the desired direction. An erroneous understanding of competitiveness often leads countries to a situation in which they are forced to restrain domestic demand and the growth of average wage in the

country in order to maintain a macro-economic equilibrium and to promote exports. Also a "collective wage cut" by means of devaluing a national currency is not rare. (WEF 2003, chapter 1.2)

3. The enlarged European Union: new kids on the block[5]

The enlargement of the European Union offers at least two sets of opportunities. On the one hand, an even larger single market is created. On the other hand, it brings together economies characterised by large wage differentials which, associated with proximity, offers many Western firms an alternative production base in their immediate vicinity. This combination of larger markets and lower production costs has *prima facie* a tremendous potential for enhancing trade, investment and growth across Europe. For firms, Enlargement carries the promise of greater economies of scale and scope, as well as offering opportunities to relocate segments of the production process which in their current setting have no longer a competitive edge. At the same time, the process is expected to offer firms of the new member states the much needed access to markets, capital and technology. (See: Pellegrin 2000, and also Pellegrin 2001)

However, these new opportunities are not as obvious as they might seem. First, their economic significance is contested by the relatively lower purchasing power of the Central and East European consumer markets. More fundamentally, the enlargement process brings together countries with significantly different levels of development, posing the question of the terms of their economic interdependence. (*Ibid.*)

Development is by no means automatic and historically non-development rather than development is the rule. (Chirot 1991) Throughout the 14th-18th centuries large parts of Eastern Europe (including the Baltics) were suppliers of raw materials and agricultural goods to wealthy Western nations, which were heavily concentrating their labour resources into high productivity sectors. (Maddison 2001, 75-80) Similarly in the 20th century, following previous rounds of enlargement of the European Union, despite heavy investments from regional development funds no vigorous convergence of income levels has been seen. (Tiits *et al* 2003, 33-35)

Economics and economic policy have practically always followed the principle made famous by Adam Smith that there is a positive correlation between the size of market and welfare. Indeed, a larger market makes possible a greater specialisation and division of labour.

In the orthodoxy of English economic policy, exporting natural resources constituted "bad trade" until long after Adam Smith and David Ricardo. The clearest statement of this orthodoxy is contained in three volumes published by Charles King in 1721. (Reinert 1999, 290) The main challenge for member state in Europe in securing economic development is the creation of an institutional framework conductive to the "right type" of business and trade.

Evidently, by the very nature of the union, with the accession several extra constraints are put on Estonia's macro-economic decision making. Within the European Union, the formulation of common foreign trade policy is the prerogative of European institu-

[5] The following chapters build partially on: Tiits *et al* 2004.

tions and no different trade tariffs are allowable for a member state. For *eurozone* members benefiting from participation in the common currency system further restraints are imposed by the European Central Bank responsible for the monetary policy, and the Stability & Growth Pact.

For these reasons in national policy making, in order to advance well-being of the people, strengthening the supply side of the economy by providing positive externalities which enable entrepreneurs to shift towards more knowledge intensive activities has to be one of the primary focuses.

Still, the European Union is much more than a mere free trade agreement or a monetary union. Despite current relatively heated debate over the plans for extensive cuts of taxes in certain new member states, it is both theoretically and practically fairly obvious that long-run growth cannot really be boosted at the cost of losing social stability. "*Those who think that all virtue is to be found in their own party principles push matters to extremes; they do not consider that disproportion destroys a state*." (Aristotle 350 B.C., Book V, IX; see also Buffet 2003)

As Adam Smith has put it beholding the despair of the 1720s in England: "*No society can surely be flourishing and happy, of which the far greater part of the numbers are poor and miserable*." (Smith 1776, Book I, VIII) With *Okun's law*[6] one could easily demonstrate even to the most cynical point of view, disregarding European values and any concerns over social sustainability, that Estonia's *jobless growth* (Tiits *et al* 2003, 28) with 10-11% unemployment currently observed (SOE 2004) is not supportive to long-run growth and it is needful to pay attention to setting up effective education, employment and social policies.

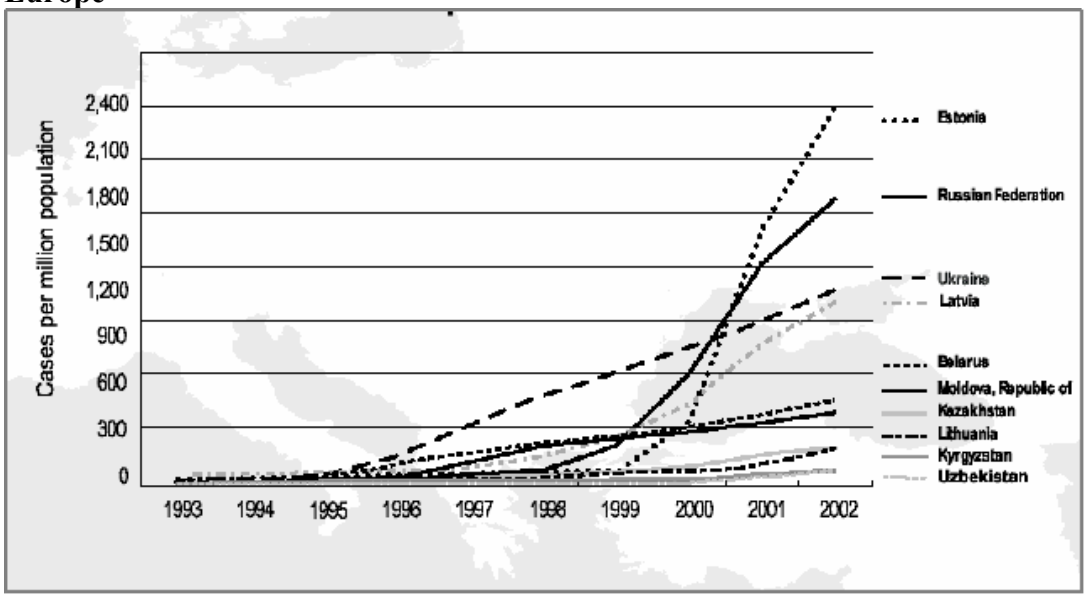
It is especially worrisome to see unemployment of 17% of the men and 27% of the women between 15-24 (SOE 2004), while demographic profiles suggest that by 2030 the total population of Estonia will be below 1 million and less than 57% of it will be people in working age. (UN 2003) This, together with 30% of families with 2 children and 45% of families with 3 children currently living in Estonia in conditions below official poverty line (SPD 2003, 127), proposes a rather bleak prospective for the future of the nation. In this context, no relief in the form of a rapid increase of the population seems likely.

Internationally there is also growing evidence that HIV/AIDS tends to spread more rapidly where poverty is extensive, incomes and wealth are distributed very unevenly, gender relations are unequal, livelihoods are not sustainable, etc. (UNDP 2004, 37) Regrettably, together with the increase of social stratification (HDR 2003), Estonia faces one of the most drastic outbreaks of the HIV/AIDS epidemic in Europe. (Figure 2)

[6] *Okun's law* provides us with an empirical relationship between the change in the unemployment rate and the percentage growth in real output, as measured by GNP. Arthur Okun estimated the following relationship between the two: $Y_t = 1 - 0.4\ X_t$, where: Y_t is the change in the unemployment rate in percentage points and X_t is the percentage growth rate in real output, as measured by real GNP. (Okun 1962) According to *Okun's law,* a potential decrease of unemployment in Estonia to 5% would give the GNP rise of 15%. In 2003 figures, this would be 16 billion EEK (approximately 1 billion euro).

Facing the demographic challenges in aging Europe it is highly likely that in 10-20 years regions in Europe will be increasingly competing with each other not only in straightforward economic terms but also in attracting the best people and in the ability to provide them with the best quality of life. (Sitra 2003, 9-10) Containment of social security costs will not make the future of the society brighter.

Figure 2. Cumulative reported HIV infections per million population in Eastern Europe



Source: UNDP (2004).

In order to support Estonia's aspirations for a rapid increase of welfare and happy life in an enlarged Europe, a series of striking social disparities in Estonia needs to be seriously addressed. The above challenges, being deeply rooted on the socio-political environment, will not be solved by being left to the market forces alone. "*Facing high unemployment, modest incomes and more unequal income distributions than many European countries, Baltic policy makers have limited room for manoeuvre. In employment policy, a paramount goal must be to improve the institutional framework for innovation and job creation*." (OECD 2003c)

The development of a *knowledge based society* and increase of the competitiveness of the economy require that the education system and the whole economy move towards new fields of activities, different from those exercised until now. A plain increase of public funding for education, R&D, employment policies, etc. do not help.

Increase of effectiveness of education and active labour market policies is not possible without a call for clear vision for the future of the nation and its future competitive edge within the Enlarged Europe. But how do we know what these new fields of activity will be? What are the numbers of expected specific work places and required qualifications respectively? There is no need to look for any extraordinary miraculous solutions. A pragmatic work with future visions must be based on the anticipation of major visible socio-economic challenges and finding solutions to them by pro-active exploitation of the latest results of scientific and technological progress.

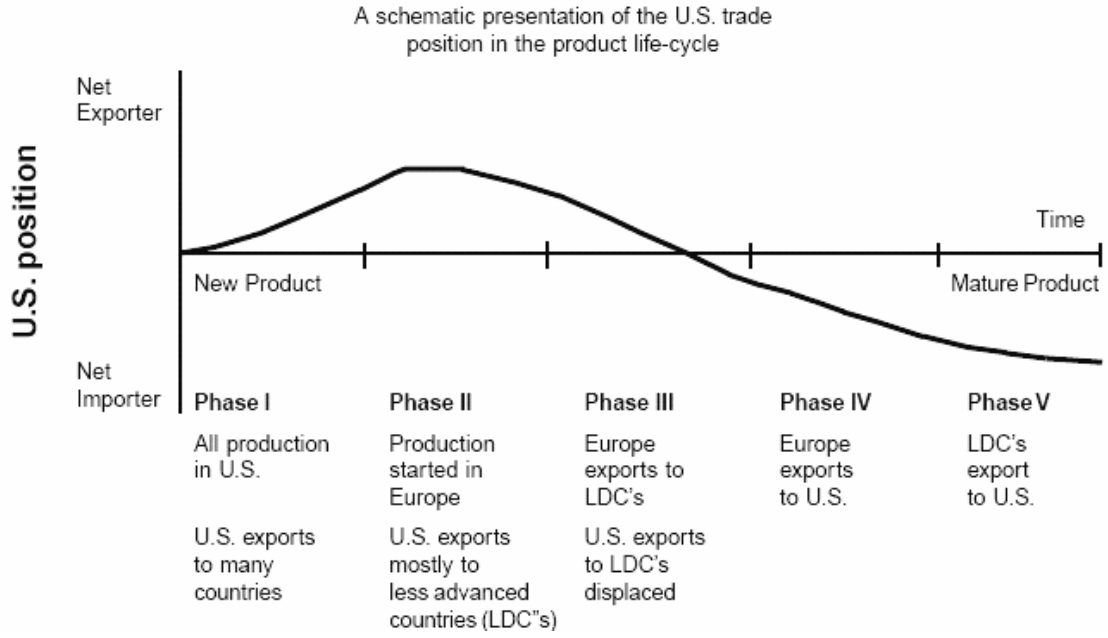
4. Industry life cycles and catching-up strategy for a small country

Economic development is not smooth and linear, but occurs dynamically and by rapid leaps. The Ukrainian economist Mikhail Tugan-Baranovski was the first to attempt to give a comprehensive explanation for a business cycle. He explained the formation of business cycles through the interaction between a financial sector and a production sector, where financial capital always looks for economic activities with ever-higher quality, as competitive advantages from research tend to quickly disappear with the distribution of knowledge. (Barnett 2001, Abramovitz 1989)

Modern economic science shows that business cycles in turn form longer waves of almost half a century which are called techno-economic paradigms. Nikolai Kondratiev's theory on long waves (Kondratjev 1926) and succeeding works of Christopher Freeman, Francisco Louçã and Carlota Perez demonstrate vividly, how constellations of radical technological breakthroughs form into techno-economic paradigms which bring about decades of major structural changes by which new technologies are diffused and adopted throughout industries, economies, societies and nations. Those, each paradigm is established by an array of co-evolving industries. (Freeman and Louçã 2001, Perez 2002)

In the initial phase of an industry or paradigm life cycle (Phase I on Figure 3), due to a limited distribution of new knowledge inevitably only very few companies and nations are able to acquire the new technologies which are created as a result of extensive scientific research lasting several years or even decades. This leads to the creation of extremely asymmetric markets where products are unique, solutions protected by patents and clients are forced to pay for products a price which is almost as high as sellers might ask. This simply gives rise to monopoly markets where "the winner takes it all" and a lot may can be won and lost as well.

Figure 3. The geographical spread of technologies as they matured in the mass production paradigm



Source: Wells 1972, 15 *cited in* Perez 2001.

For the next phase, the technical parameters and costs of these innovative products becomes suitable for mass consumption. The market grows explosively as a result of competition and a decrease of market prices and a respective new infrastructure is created. This is also the time when the largest profits are made on the market. The explosive growth that occurred in such manner in the mobile communications sector in the second half of the 1990s explains largely the phenomenal economic growth in Finland which "collected" profit from investments into research and development related to telecommunications since the 1960s.[7] (Rouvinen and Ylä-Anttila 2003)

As new technologies and related knowledge diffuse and get imitated, also the competitive advantages originally rewarding innovators with short term monopolistic powers are lessened and finally get completely washed away. Accordingly, products get cheaper and profit margins diminish; production is also set up in other industrialised countries close to major export markets (Phase II on Figure 3). With the further diminishment of returns production is relocated to less developed countries (LDC) where cheaper inputs such as lower costs of labour, cheaper natural resources and energy are available, until finally LDC's exports completely replace the production in industrialised countries. (Phases III to V on Figure 3). In case of mobile communications systems this is expressed in the increasing dominance of East Asian companies.

The rapid distribution of knowledge and technology (particularly in developed countries) means that the productivity of a certain technology cannot grow endlessly. Its slowdown occurs inversely to the distribution of technology, as competition is becoming fiercer and the potential of relevant technology is being exhausted. In the given situation a new growth of productivity is provided by new technology with a corresponding paradigm. New technology gives rise to asymmetric markets and division of knowledge. Thus, policies of research, development and innovation must always be based on a specific technology and its development stage.

Thereby economic development is a process by which nations upgrade, via investments, education and indigenous technological efforts, their relative position in global production networks by gradually moving towards more knowledge intensive activities. Thereby the uniqueness of products achieved through R&D efforts, cutting edge design, etc. replaces efficiency, as the primary source of competitive advantages. (See for example: Reinert 1999, 288-291; Porter 1990)

The initiation of major scientific and technological breakthroughs takes decades of heavy investment into basic research and technological development to emerge. For that reason it is foremost a prerogative of large wealthy nations. To small countries the formation of technology trajectories leading to major breakthroughs is largely an exogenous process. Even, if a small nation possesses the home base of a high-tech multinational corporation, the policies of which it can choose to subsidise or not, it is still heavily dependant on a few large and wealthy 'core innovator 'nations, which produce most of the scientific and technological breakthroughs in the World.

[7] The respective investments into education, research and technological development were made in Finland by the state at first and since the 1980s also increasingly by private companies. (Steinbock 2002)

It is highly doubtful that national broad scale (minute in absolute terms) investments into academic research in small countries will lead via tiny spin-off companies to the emergence of new globally dominant industries and thus to socio-economic catching up. Because of the immense resource constraints, small countries are fundamentally unable to replicate the growth strategies of large countries. (van Beers 2003)

Yet, also small countries are increasingly constrained by their inability to achieve the desired economies of scale in medium- and low-technology areas. It is sometimes even believed that small countries are fundamentally geared towards medium-tech activities. (See for example: van Tulder 1991 *cited in* van Beers 2003)

A strategy possibly applicable to clusters of domestic SMEs in a technologically relatively backward country could be drawn from the Taiwanese experiences of recent decades. This approach would aim at addressing local socio-economic challenges while seeking for global economies of scope in specific niche markets developed through *disruptive technologies*. (Ernst 1998)

Yet, in a tiny country this strategy would prerequisite a highly specifically targeted education, research and technology development efforts and possibly some rearrangement of economy. In this context, the recent Finnish success in the sector of mobile communications is rather an exception brought by happy coincidence and a lot of good luck. (Steinbock 2002)

The Irish vast success in the 1990s was primarily based on the ability to target foreign investments into industries in early phases of the emergence of new high-tech markets (Phases I & II on Figure 3 above). Primarily, U.S. multinationals active in the information and communications technologies sector were provided with an attractive location for production and with the entry to a European *single market*.

While Irish low taxes making transfer pricing possible was definitely an important factor in attracting investors, the ability to quickly adjust the education system and to make available a sufficient amount of well qualified staff, was crucial. For the advancement of national prosperity it is absolutely vital to avoid the appearance of a 'dual economy' and to ensure the establishment of proper backward linkages between foreign investment enterprises and indigenous companies. (Barry 2000)

The Irish experience also proves that economic integration into the EU may be a necessary, but certainly is not a sufficient condition for a peripheral country to be an attractive location for multinational corporations to invest in. Ireland has been fortunate, that U.S. investment has **not** been attracted primarily into sectors, e.g. wood, food and the production of human labour intensive goods, in which the country had a traditional comparative advantage. (Görg and Ruane 2000, 419)

Despite the fundamental disability of small countries to compete with large nations in large scale R&D and the establishment of platform technologies, public investment into basic research is still highly wanting for development of human resources and advancement of the quality of higher education. To be able to acquire via FDI an adequate role in global production networks and to be able to upgrade it over time, well targeted endogenous technological efforts are still needed. (Dunning 1998, UNIDO 2002, 105-115)

While the Finnish predominantly domestically based approach embodies much greater risks for technologically backward economies than the Irish inward FDI based strategy, these strategies still can and should be combined to back up each other. The existence of a certain domestic scientific technological strength in specific domains of strategic interest, would call in the initial phases of the emergence of new markets primarily for focusing on strengthening indigenous industries, which would be later backed up by very specifically targeted inward FDI, or vice versa.

Both approaches call for careful priority setting in RTD investments to ensure the existence of a minimum knowledge base in all areas of interest, while investing strongly into few areas most supportive to the socio-economic context of a specific country (incl. possibilities for upgrading the existing traditional industries). Therefore, both strategies are vitally dependant on good foresight in relation to the emergence of major new technology diffusion trajectories and markets. Also, perfect timing is absolutely crucial.

5. Global frontiers in science and technology

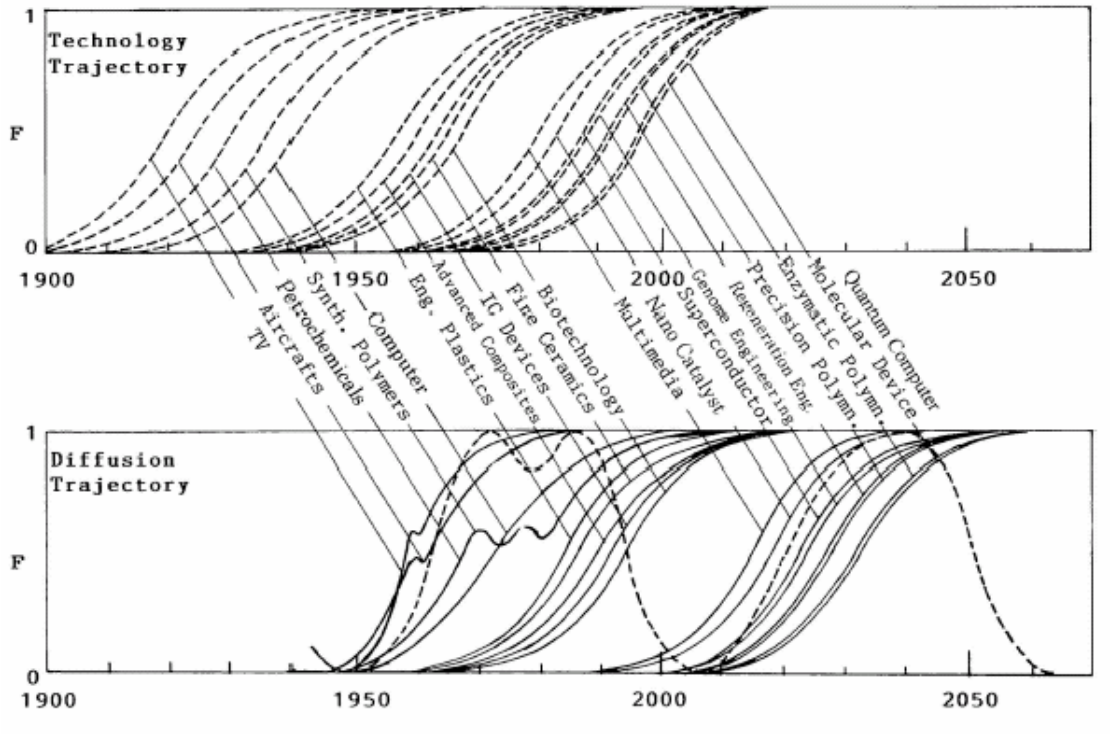
Various prominent sources anticipate a socio-economic revolution forthcoming within the next 10-15 years that is based on scientific and technological breakthroughs in the areas of convergence of information, bio- and nanotechnologies and cognitive sciences. It is expected that subsequent scientific and technological breakthroughs in bio- and nanotechnologies, will radically change almost every aspect of everyday life and offer possibilities for faster socio-economic development than any other area of science and technology. (See part II, page 29)

Similarly to the science and technology policy priorities since the 1970s in Finland (Lemola 2003, 59), the Soviet Union and many OECD countries, the same key areas for research and technological development are also highlighted in Estonian national research and development strategy 2002-2006: *Knowledge-based Estonia* (KBE 2001). Nonetheless, little has been done in actual implementation of R&D and innovation policies in Estonia to specifically follow these priorities.

Indeed, in the 1990s Estonia was successful in the early take-up of modern ICTs rested on investments made into research and higher education throughout earlier decades. Likewise, OECD reports that about half of the recent productivity increase in developed countries has come from production and application of information and communication technologies. (OECD 2003a, OECD 2003b) Nonetheless the straightforward economic impact of bio- and nanotechnologies has been barely noticeable. Occasionally, this even poses certain questions on the viability of the promise of the socio-economic significance of bio- and nanotechnologies for future.

The key to understanding the above apparent inconsistency lies in understanding the above described industry life cycles. The immense global success of information and communication technology industries in the 1990s built on investments made into research and technology development since the 1940-1950s. Similarly, observing the today's volumes of research investment one can see what is "on the pipeline" for diffusion of new technologies. Thereby likely future breakthrough technologies and industries forming coming techno-economic paradigms are predictable. (Figure 4)

Figure 4. Emergence and diffusion of new technologies



Source: Hirooka 2003.

For large nations, investment into radically new breakthrough technologies partially renders self-fulfilling prophecies possible with regards to future socio-economic development. The higher the ratio of investments into research and technology development today, the more likely is the future emergence of the respective technologies, products and industries. Nowadays, investments into research for the development of bio- and nanotechnologies are immense and increase rapidly. (See Figure 5)

Luckily for the small countries, there is a large body of public data available in the form of policy papers, scientific publications, patents and market data, which can and should be used for informing policy making.

Figure 5. Government funding for nanotechnology R&D, mio USD, April 2002.

	1997	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Western Europe	126	151	179	200	225	~400	
Japan	120	135	157	245	465	~650	
USA*	116	190	255	270	422	604	710
Others	70	83	96	110	380	~520	
Total	**432**	**559**	**687**	**825**	**1502**	**2174**	
% from 1997	**100%**	**129%**	**159%**	**191%**	**348%**	**503%**	

Source: DTI 2002, 18.

* U.S. investment does not include non-federal investment eg. California.
"Others" include Australia, Canada, China, Eastern Europe, Former Soviet Union, Korea, Singapore, Taiwan and other countries with nanotechnology R&D.

Though various market estimates vary greatly, the market for biotechnologies, in which soybeans and cotton will still hold the lion's share, is predicted to reach over $20 billion by 2006. The potential market for "white biotechnology", *i.e.*, the use of genetically modified plants for the production of vaccines, renewable sources of energy (e.g. ethanol), biodegradable plastics, and other goods could be much larger, possibly up to $100–500 billion per year by 2020. (Bernauer 2003, 6)

In 2003 the total global demand for nanoscale materials, tools, and devices was estimated at $7.6 billion and is expected to grow at an average annual growth rate of 30.6% to reach $28.7 billion in 2008. It is believed that the nanotechnology market will be growing more than twice as fast as either the biotechnology or global informatics sectors. (BCC 2004)

While the size of the market and the conditions of entry are crucial for strategising for national policies, still no 'guarantees' on the socio-economic acceptability of new technologies could be ever given. There is always a risk that despite scientific and technological availability, certain solutions could be outright rejected by society.[8] Unlike multinational high-tech corporations, individual entrepreneurs are never able to fully bear the risks related to the acquisition of knowledge and the development of new technologies.

Only the state can bear the risks and ensure the positive externalities that are vital to the economic development (for example, by investing into bio- or nanotechnology today). Scientific and technological risks need to be borne reasonably and coherently. Such risks should never be borne separately in hi-tech sectors and so-called traditional industries, but they should be handled together: updating traditional economic activities through the application of new key technologies (for example by introducing ICTs to transports and logistics, or updating wood and chemical industries based on biotechnology, etc).

Eventually, over the forthcoming decades new technologies will diffuse throughout nations, be they large or small, developed or developing. In a globalised world, this will even happen despite a complete ignorance of scientific progress and a disability to invest into domestic research and education. Yet, the better the nation is prepared, the closer it will be to the initial emergence of new industries and markets and the better new technologies can be integrated into an existing production system. In *knowledge based society* this predominantly determines the wealth of nations.

6. Future specialisation scenarios for Estonia

The future cannot be predicted. It is made by a combination of today's socio-economic environment and policies, which either form or constrain future opportunities, and a chance. To be able to properly address, within the relatively loose framework of the EU *Lisbon Strategy* (Lisbon 2000, EC 2003b), Estonia's burning socio-economic challenges and to be able to lay proper foundations for the future, copy-and-

[8] In the period after World War II nuclear power engineering was considered an "all-mighty" technology which has a potential to change the world. For several reasons, including social acceptability of this technology, this never happened.

paste policy making is clearly of no use. A strategy can only prove successful if deeply rooted in local conditions and aspirations for the future.

In the Estonian socio-economic context, the above considerations related to the enlargement of the European Union and to social inclusion, global relocation of industries, global investment trends in cutting edge science and technology, possible policy options for catching-up strategies could be best described through the following series of medium- to long-term mini-scenarios, a combination of which, depending on the actual advancement of public policies, seems likely to shape Estonia's future:

A. Business as usual

Aiming at a greater unison between education and predominantly Estonian current specialisation pattern, immediate needs of vocational education are followed in structural adjustments and a strengthening of education and active labour market policies. For the development of exports, priority is given to specific indigenous industries where Estonia possesses a classic Ricardian comparative advantage, i.e. wood and furniture, and textiles (Tiits et al 2003, 25). Through a series of tax cuts attempts are made to hold (wage) costs down. Simultaneously also cost cuts and the achievement of extra efficiency gains are required from research, education, health care and social security systems, where due to downward demographic trends an otherwise proportionally quite excessive increase of public expenditure would be required.

Though the difficulty with the dominant version of the comparative advantage theory, due initially to Heckscher and Ohlin, is that it is based on the idea that all nations have equivalent technology but differ in their endowments of so-called factors of production such as land, labour, natural resources and capital.[9] However, this approach leaves several factors, like technological change and economies of scale, which are crucial to growth and the development of *knowledge economy* completely intact. (Porter 1990, 11-21) Therefore, this can easily prove to be a scenario for specialisation on "bad trade", being uneducated and poor.

B. Southern Finland

One of the further factors completely disregarded in the previous scenario is the possible impact of the EU enlargement and future foreign direct investments to the development of an international specialisation pattern of the Estonian economy. Yet, as seen in the Irish case (Barry 2000), FDI can easily prove to be a driver, powerful enough, to alter almost completely the former specialisation of a small economy.

Owing to the simplification of trade brought about by the EU enlargement, the smallness of Scandinavian countries, and increasing pressures for lowering costs and reaping greater economies of scale, a series of low- and medium-technology production facilities of Scandinavian food, wood and metal works clusters is relo-

[9] Modern versions of Ricardian theory have assumed one factor of production (labour) and that countries differ in the amount of labour required to produce a good. (Dornbusch *et al* 1977)

cated to the Baltics. This includes predominantly resource intensive activities, like production of foodstuff, various metal- and woodworks, continued expansion of labour intensive electronics assembly facilities, various international service centres, etc.

In parallel, indigenous industries in low- and medium-tech sectors, such as textiles and chemicals, are facing increasing cost competition and diminishing returns. Certain sectors, e.g food, chemicals, energy, are additionally depressed due to difficulties in meeting the requirements of acquis communitare, which provides additional pressures for consolidation. (Tiits et al 2004) Thereby also further mergers and foreign acquisitions are introduced.

This scenario implies substantial shifts in ownership structure and Estonia's comparative advantage. As a prerequisite for public administration, it also embodies for vigorous co-ordination of employment, education and innovation policies at supra-national level. Nonetheless, not all economic activities in want for relocation from Scandinavia due to the loss of cost competitiveness need to be beneficial to Estonia.

C. Play off

Acknowledging the constraints of smallness and the limitations of foresight in a technologically relatively backward country, Estonia follows international technological efforts and markets by focusing on attracting foreign investments in areas related to emerging disruptive technologies, e.g. quantum IT security systems, ubiquitous IT systems, bio-nanomedicine and others. Serious efforts are to be put into an FDI targeting scheme and the establishment of backward linkages with indigenous enterprises. Thereby a radical shift in the knowledge intensity of the indigenous industry is seen over medium to long term.

In parallel, based on the existing technological strength, within the competence centres scheme, major indigenous historically determined specialisation areas are strengthened and expanded based on strategic long-term roadmaps prepared in collaboration of researchers and industry consortia. This applies for the development of radically new bio- and nanotechnology systems, but is equally true for new generations of information systems, based on bio-nanoelectronics, biotechnologically enhanced wood technologies, cognitive systems and several other areas. Based on the above-mentioned long-term technology roadmaps, the government provides extra support in the form of the development of human resources (incl. active labour market policies, life-long learning and public goods R&D), ensures the availability of long-term investment capital for technology upgrading via inward technology transfer, etc.

Socio-economic development is not a zero sum game. Neither is the establishment of socio-political institutions, conductive to growth, a simple redistributive task. In order to create preconditions for the above structural changes, the preparation and coordination of public policy need to be very innovative themselves. Essentially, there is a need to develop a comprehensive policy strategy, which would enable horizontally well co-ordinated structural reforms in education, employment and social policies.

> For a successful implementation of a combination of the above FDI and disruptive technologies based strategies, highly professional public services and regular foresight processes embedded into the national policy making system are inevitable prerequisites. To prepare a national development strategy, which would be widely accepted in society, corporatist and political rivalry need to be overcome and clear objectives need to be set by the government's collaboration with academia, the business community, the financial sector and other relevant stakeholders. (EC 2002, Chapter 15)

7. Conclusions

None of the above or other imaginable scenarios embodies a full automatism or should be taken as a self-fulfilling prophesy. Being drawn in black and white, such mini-scenarios can only provide a stimulus and an inspiration for strategic policy thinking.

For Estonia, the transition to truly high-tech R&D intensive activities is a gradual long-term process starting from the modernisation of higher education and research systems streamlined by capacity-building in inherently research intensive sectors. It is therefore unrealistic to expect any rapid breakthroughs. Moreover, targeting exclusively high-tech is not a viable approach. For catching-up upgrading traditional economic activities and achieving close to full employment, brought about by life-long learning, effective active labour policies.

The main conclusions of this paper refer to general prioritisation and timing of the above public policies, and related investments. It is recognised that in order to properly meet the challenges ahead, instead of the currently prevalent policy stance for the advancement of "commercial science" and the initiation of spin-off activities, a much stronger focus needs to be put on the preparation for a longer term. Innovation policy has to be made specific to technologies and prevalent economic clusters in the Baltic Sea region.

Acknowledging the very logic of product life cycles and the evolution of techno-economic paradigms, in short term a much greater public policy focus should be put on the monitoring of global industrial change and on the support to upgrading the domestic industries. In the development of an information society in the coming years, the main innovation policy focus should be on a wide-spread take-up of ICTs in the provision of goods and services throughout the society.

The prospective expansion of Scandinavian contract manufacturing plants may prove positive if this is to contribute to the increase in employment in Estonia, and the emergence of "dual economy" is avoided by ensuring proper spillovers of know-how and technologies. To allow this to happen, in the lower end of the value chain, in a well focused manner, great attention has to be paid to vocational education and re-training.

While opting for success in medium and long-term, massive capacity-building in education and research in forthcoming breakthrough technologies should be sought. (See Figure 4) For the next 10-15 years, this should foremost include a radical broadening of Estonia's existing competence base in the information technologies, bio- and

nanotechnologies, and cognitive sciences (NBIC). By doing so sound human resources would be established for a likely bio- & nanotechnology based paradigm forthcoming possibly over the next 15-20 years.

As new NBIC technologies start to be brought to the market, Estonia's current disadvantage of low national investment in traditional industries should be played as strategic advantage. – In the IT paradigm, big players will be increasingly *locked in* via their large-scale investments into production facilities into their, then outdated, technological trajectories. As Estonia has no massive industrial investments to defend, this gives her a certain freedom to be opportunistic by trying to enter various new niche markets early and to develop *disruptive technologies*. Also, to exploit these possibilities, Estonia should proactively seek for ways to enter new markets via targeting inward FDI from non-traditional to Estonia's investor countries (e.g. U.S., East Asia and China, etc.), which would be interested in setting up production facilities for an early entry in the European *single market*.

Finally, most importantly one has to acknowledge that rapid growth involves strong political leadership and co-ordinated organisational changes in each of these three domains: the business model, production capabilities, and skill formation. No one of the three elements can contribute to growth independently of a mutual adjustment process involving all three elements. Therefore, only an innovation policy deeply rooted in local context, which facilitates the development of the capabilities which constitute entrepreneurial firms and cluster dynamics, offers the potential to advance the nation's competitive advantages in high value added activities. (Porter 1997, Best 2000)

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Part II

Towards modern STI policy-making in Estonia[10]

1. Abstract

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

2. Techno-economic paradigms and the development of capitalist economic system

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

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

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

The history of economy shows that these paradigms have lasted for nearly half a century[11], starting with explosive development in narrow fields of technology, until the technology becomes so cheap and offers a multitude of different applications, essentially allowing all branches of industry to sharply increase productivity. Increased productivity and the ensuing scale effect (production costs decrease as the output increases) do not result in an international price reduction, but rather in an extensive rise of wages.

Such technologies will presumably allow an abrupt or even decisive improvement in productivity now and in the decades to come. When improved productivity, based on

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[10] Re-printed, without change, from *TRAMES Journal of the Humanities and Social Sciences*, 7, 1, 2003, 53-62.
Parts of this paper are based on: Tiits *et al* 2003.

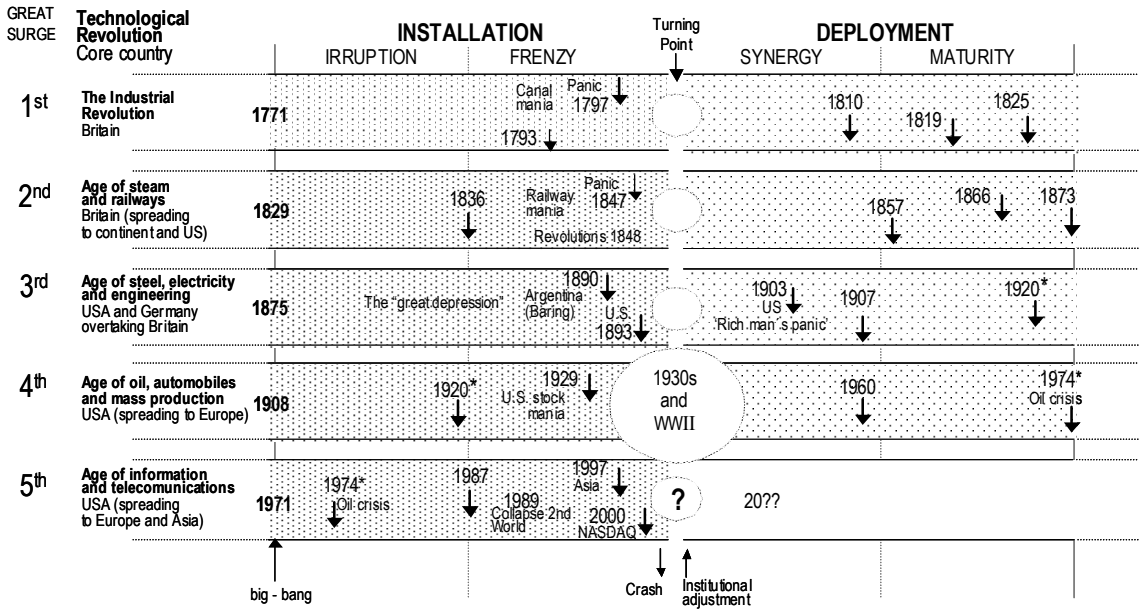
[11] This phenomenon was first observed in the capitalist economic system by Russian economist Nikolai Kondratjev in 1926. See also: Freeman and Louçã 2002.

a certain technology, expands and penetrates other sectors and in turn improves productivity in those other sectors, it means a vigorous economic development.

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

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

Figure. Five successive techno-economic paradigms and major financial crises



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

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

3. Machines inside our cells - visions for 2020+

The size of the 1st transistor invented 55 years ago was approximately 10 million times of that of the first experimental single-molecule transistor described in *Nature* magazine in June 2002 (Weiss 2002). Recently, researchers at the University of Okla-

homa have demonstrated that the 19 hydrogen atoms in a lone liquid crystal molecule can store at least 1024 bits of information (Knight 2002). These developments hold a promise of opening up a development of completely new generations of data processing systems. It allows for the explosion of all kinds of machine intelligence and gadgets, drastically diminishing in size.

In their report "*Orientations for WP2000 and beyond"* (ISTAG 2000) on the future priorities for research and technological development, the Information Society Technologies Advisory Group (ISTAG) to the European Commission focuses on the concept of Ambient Intelligence, where humans are constantly surrounded by intelligent environment interfaces supported by computing and networking technology. Here, the three most important characteristics of this vision are: connected *always* and *everywhere*, the use of services is *enjoyable*.

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

Trends like that are foreseen by the famous inventor and future visionary Ray Kurzweil. He writes: "By 2009, computers will disappear. Displays will be written directly onto our retinas by devices in our eyeglasses and contact lenses. In addition to virtual high-resolution displays, these intimate displays will provide full immersion into visual virtual reality. We will have ubiquitous, very-high-bandwidth wireless connection to the Internet at all times." (Kurzweil 2000)

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

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

But there is even more to the fact that this is not just loose speculation or an idle dream: it is work in progress at Cornell University and many other places around the world. We see several already on-going research projects, which head in this direction. They aim at making nanotechnology implants doing things that nature simply cannot: such as making drugs or generating electricity (Sample 2001).

Ian Sample reports in the New Scientist magazine: "Smart implants that deliver drugs precisely when they're needed are already near to hitting the market. Also on the way are electronic devices that tell cells to make specific hormones when your body needs

them, and electricity generators that assemble themselves inside a cell and then tap into the cell's own energy source for the power to run. There is no question that machines are beginning to infiltrate the biological workings of life.

The first medical application of implantable nanotechnology is currently proving its worth in trials. Tejal Desai at the University of Illinois has developed a nano-engineered implant that could mean people with diabetes would no longer have to inject insulin." (Sample 2001)

Over the last 50 years, we have seen the evolution of pacemaker technologies as an accepted form of intrusion into the human body. Recently, the U.S. Food and Drug Administration permitted the use of implantable ID chips in humans, providing they are used for "security, financial and personal identification or safety applications." (Scheeres 2002)

For beneficiaries, implant technologies involve possibly some future advantages, like rapid math, memory capacity or communication by thought.[12]

And here again, the on-going *cyborg* projects, playing around with implants connecting human nervous system and a computer and thence to the Internet via bidirectional link, are the lively proof of fast developments in these areas[13] (Warwick 2002)

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

With these latest developments in implant technologies, a completely new set of issues, related to privacy, ethics and responsible conduct of science emerges. All of it takes us very close to the Kurzweil's existentialist question - how to distinguish between the human person and the machine - when your computer has become emotional, and displayed the following message on the screen (on your retina): "I'm lonely and bored, please keep me company". Kurzweil (2000)

This is pretty scary.

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

[12] The later is sometimes seen as something which would enable to overcome the problems of very slow, inaccurate and often terribly erroneous analogue voice communications between the humans.
[13] See also http://www.kevinwarwick.org/

4. Implications for science, technology and innovation policies

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

Converging info-, bio-, nano- and cognitive sciences are likely to form the basis of the next techno-economic paradigm.[14] These technologies are still very much in the basic research phase, with rather limited economic effect in short term. While biotechnology has already a number of specific application areas like agriculture or biomedicine, most of the bio- and nanotechnology products today are essentially R&D products, establishing knowledge base for the future RTD activities. Neither biotechnology nor nanotechnology products are *really* cheap and readily available for massive exploitation to improve the productivity throughout the economies yet.[15]

This means that R&D and innovation policies must be always built on a specific technology and its specific stage of development. Economic policy has to be targeting specific technologies and development of economic clusters (OECD 2001 and Porter 1990).

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

Therefore, when designing innovation strategies or public policies it has to be acknowledged that in today's globalised world, multinational corporations provide 80% of private sector research and development expenditure, and they produce and control the majority of the world's high-tech solutions (Dunning 1993). In-depth integration into global production networks and one's subsequent upgrading of competitive advantages is therefore crucial.

If *catching-up* countries, like Estonia, are about to benefit from ICTs, identification of more promising emerging industries, specialisation and rapid industry acquisition, clustering and in-depth integration into larger supra-national production networks should be considered. The same is true for mature biotechnology based industries, like

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

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

biomedicine, where large multinationals dominate the market, and smaller newcomers have no chance.

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

5. Candidate countries' response to the Lisbon strategy?

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

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

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

Throughout the 1990s, a number of economists have seen foreign direct investment lead technology transfer, gains in productivity increases, related organisational learning and spillovers into domestic enterprises, as the main engines of economic *catching-up* process in the European Union candidate countries (Radosevic 1999).

At the same time, continuing problems with maintaining a balance of the current account in most of the CEEC, as well as widening income/productivity growth gap (at least in some of the countries in the region), put extra pressures to the macroeconomic stability. Therefore, the success in taking up novel ICT solutions, as any other foreign technologies, praised by many, needs urgently to be translated into innovative industrial capabilities, and the real knowledge economy.

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

In this process, the government policies (be they explicit or implicit), incentives for technological upgrading, the international business environment, and good luck are all important shapers of the operating environment of enterprises and the competitiveness of enterprises depends on production factors, demand, strategic choices, co-operation and competitive environment (clustering) (Porter 2002).

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

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

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

So far, the analysis of transition and developing countries conducted by UNIDO shows that only a few of them have managed to repeat Ireland's performance: to combine their reliance on foreign direct investment with a strong industrial policy while dealing purposefully with the areas in which they desire to enter the market, and developing skills necessary to that end. Most of the countries have applied far more passive foreign investment policies, benefiting from sound macro-economic equilibrium, business support, attractive location and good luck. The less successful developing economies – and there are many – have not managed to implement any of these strategies properly (UNIDO 2002).

6. Implications for Estonia

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

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

Therefore, for the future economic development of a *caching-up* country, establishing strong scientific and industrial specialisation in the areas, where the needs of home market seem to precede the prospective future needs of incomparably larger international markets, or where competitive production facilities in high value-added industries can be offered to the major global players, is essential. In this process, science, technology and innovation policies have to become a much stronger part of the broader structural agenda (EC 2002).

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

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

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

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

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

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