CREATIVE DESTRUCTION MANAGEMENT:

MEETING THE CHALLENGES OF THE TECHNO-ECONOMIC PARADIGM SHIFT

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Tallinn 2006

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This publication has been produced with the assistance of the European Union. The contents of this publication is the sole responsibility of PRAXIS Center for Policy Studies and can in no way be taken to reflect the views of the European Union.

Delegation of the European Commission in Estonia: www.euroopaliit.ee.

Editors: Tarmo Kalvet, Rainer Kattel.
Layout: Kristjan Kaljund

ISBN-13: 978-9985-9667-2-3
ISBN-10: 9985-9667-2-4

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Abstract

Economic development and national competitiveness are very much dependent on the quality of economic activities, and especially on the intensity of activities in terms of knowledge, technology and skills. The challenge of economic growth is more difficult for small nations than for large nations, but there are technological windows of opportunities that can be utilised via lesson-drawing from successful states. For instance, while the Baltic States are currently facing major problems, there have been successful states as well in the Baltic Sea Region. The Baltic States are falling behind their Scandinavian neighbours in most industries. They face growing challenges in strategic choices and in policies. In particular, the challenge for them is to catch-up with the level of productivity and living standards of Scandinavian countries and most of Europe. The European Structural Funds has become one of the key instruments in strategic policy making of all new EU member states. For the structural funds period 2007-2013, Baltic States need to coordinate policy actions in order to upgrade and develop their economies. The book is a product of two projects: Creative Destruction Management in Central and Eastern Europe: Meeting the Challenges of the Techno-Economic Paradigm Shift (2000-2001), originally initiated for the Council of Europe; and a project funded by the Phare Cross-Border Co-operation Programme (2005-2006).

1. Sources of Competitiveness and Economic Development

Estonian-born economist Ragnar Nurkse (1907–1959), an outstanding researcher whose work examined and sought solutions for the vicious circle of poverty in underdeveloped countries, has argued that economic development hinges on the size of the market, its purchasing power as well as other interlocking disincentives to investment, savings, and capital formation. One of his central arguments is that poor countries might never follow the development path of the industrialised countries because they might never attract enough capital to fuel the development cycle (Nurkse 1953).

The Norwegian economist Erik S. Reinert further developed in detail Nurkse's approach to development given contemporary global dynamics. Reinert (1999) argues that economic activities are *not qualitatively alike*. Achieving returns to scale is more likely in the industrial sector, as well as in certain knowledge-intensive services, than in other sectors of the economy. The quality of economic activity depends on the intensity of knowledge, technology and skills. The tacit nature of knowledge makes competition dynamically imperfect – that is, entrepreneurs do not know exactly how one generates its product or service. This (partial) lack of information on the competitor's side gives an entrepreneur its competitive advantage — one may penetrate larger markets and even attain monopoly status in certain markets or market segments for a limited period of time. This, in turn, allows the monopoly to dictate high prices on the market.

At a more general level, economic development is neither smooth nor linear. The alternation of product generations, which is triggered by new knowledge and values, causes the cyclical nature of socio-economic development and institutional change. These cycles are referred to as 'techno-economic paradigms' (Kondratjev 1926; Freeman and Louçã 2001; Perez 2002). Paradigms arise as a result of massive investments in certain radically new scientific inventions and their concomitant commercialisation, as well as the extensive use of the corresponding technologies characterised by growing productivity.[1]

Based on remarkable economic patterns in history, paradigms last for approximately half a century – initially developing in a narrow technological sphere, until the technology in question provides several different opportunities for use and has become so inexpensive as to enabling practically all industries to abruptly increase productivity. The enduring techno-economic paradigm, the age of information and telecommunications, started in 1971 with the invention of the computer chip. The next two decades will most probably see further massive growth of ICT-based technologies and solutions, and the continuous search for new technological solutions that would render new solutions and make productivity growth possible (i.e., large investments in bio- and nano-technologies).

Further, the rapid spread of knowledge and technologies (especially in the developed world) implies that the productivity, arising from a particular technology, cannot improve endlessly. As competition tightens and as the technology exhausts its potential, productivity will decrease in inverse proportion to the spread of technology. In such a situation, a new technology and the broader paradigm within which it is based, can offer new improvement in productivity. Thus, R&D and innovation policies must always be based on the particular technology and its state of development (for a discussion of these issues in the Estonian context, see Tiits *et al.* 2003, 2006).

Notwithstanding some progress in academic research and public policy analysis in recent years, the relationship between the size of a nation, on the one hand, and its possible consequences for economic development, politics and public policy, on the other, remain unclear. While the 'general inference of the theoretical literature is that the disadvantages of small size, i.e. of economic sub-optimality, outweigh any potential advantages' (Armstrong and Read 2003), some researchers argue that small states (cf. Archer and Nugent 2002) are no different from large states, hence the former should receive the same political advice as the latter (Easterly and Kraay 2000). The more appropriate view seems to be that small countries are not simply smaller versions of large countries and that smallness is neither a necessary nor sufficient condition for slow economic development (Srinivasan 1986). But at the same time, the challenge of economic growth is much more difficult for small nations than for large nations (Robinson 1963). In particular, processes of transition and globalisation have brought new theoretical and practical challenges in the development agenda (see Samuelson 2004; Audretsch 2004). These processes have impacted on the economic development of small states. For instance, many small transition economies experience uneven economic growth at home despite their successes at export markets (Stiglitz and Godoy 2006; Stiglitz 2001; Piech and Radoševic 2006).

All these open up the question: can small states find and exploit a technological window of opportunity (Perez 2001) in the way Ireland and Finland have done in the last 20 years? History of economic policy teaches that economic (industrial and innovation) policies emerge often through processes of emulation and lesson-drawing (Reinert 2007).

1 – For an overview on techno-economic paradigms, see the presentation of Carlota Perez on a seminar organised by PRAXIS Center for Policy Studies at the Ministry of Economic Affairs and Communications, 27 September 2002, at http://www.praxis.ee/innovation/workshop/.

In the 17th and 18th century Europe, small Italian and Dutch cities served as models for German and USA policy makers (see, for instance, Hamilton 1791). Today, Finland and Ireland serve as examples of very rapid growth and change. However, when drawing parallels one has to always consider if these insights are specific to certain time-period and technology. For instance, technological and policy regimes have changed remarkably in today's world, moving away from the era of a relatively closed national markets and scale-sensitive mass production manufacturing (see Chang 2002). Yet, it is fair to say that successful economies have followed what we call balanced mix of development policies: from economic to labour market and financial policies. And indeed, there is a space for lesson-drawing. This book analyses the relations among different technologies, socio-institutional settings and policy, as well as provides policy recommendations.

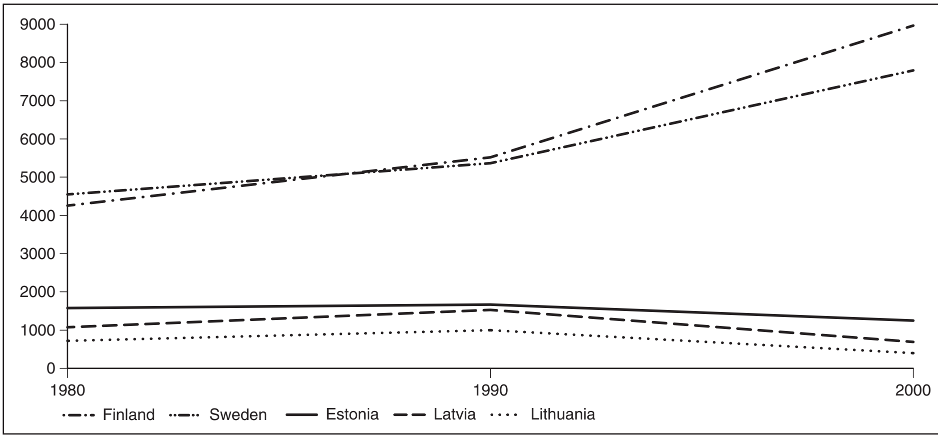
2. Economic Development in the Baltic Sea Region

'The Baltic Sea Region is home to a strong and prosperous economy' (Ketels *et al.* 2005, 14) is a statement often found in various policy reports and political speeches. The Baltic Sea Region is geographically stretched – from Russia in the East to Norway in the West, from Germany and Poland in the South, to Sweden and Finland in the North – and so are the countries within it and their respective economic and social characteristics. With the accession of Estonia, Latvia, Lithuania and Poland to the European Union in 2004, all countries in the region, except Russia, are now part of one integrated economic area, subject to common rules and regulation in various fields. Sources of economic development and competitiveness, however, remain different in different countries. Nordic countries have proved highly resilient and adaptable to fast changing global environment, and represent some of the most successful nations both in terms of economic and social development.

However, various international research projects, including those conducted by PRAXIS Center for Policy Studies, indicate that institutional framework created in the Baltic countries through liberalisation encourages economic activities that are *not* R&D- and innovation-intensive, but rather the opposite: low technology and relatively cheap labour based activities.[2] Generally speaking, it is much more lucrative for an entrepreneur to engage in low technology activities than in very uncertain and highly competitive activities related to high technology. For instance, the technology-intensive exports of Estonian companies have been declining for several years. This means that the Estonian economy fails to generate the value added necessary to cover the current account deficit. But this does not mean that Estonian companies are not doing well. The competitive advantage based on cheap resources is disappearing – the more technology-intensive the Estonian companies become, the more complicated their situation today because they lack the means, skills and experience necessary for withstanding severe international competition. At present, the Estonian economy is literally not sustainable. The situation is similar in other Baltic countries. Figure 1 illustrates that all three Baltic states have gone through rapid and strong de-industrialisation process following the regaining of their independence in the early 1990s. Figure 2 suggests that this process of de-industrialisation also manifests the incessant lagging behind of the Baltic states in the region in terms of GDP per capita.

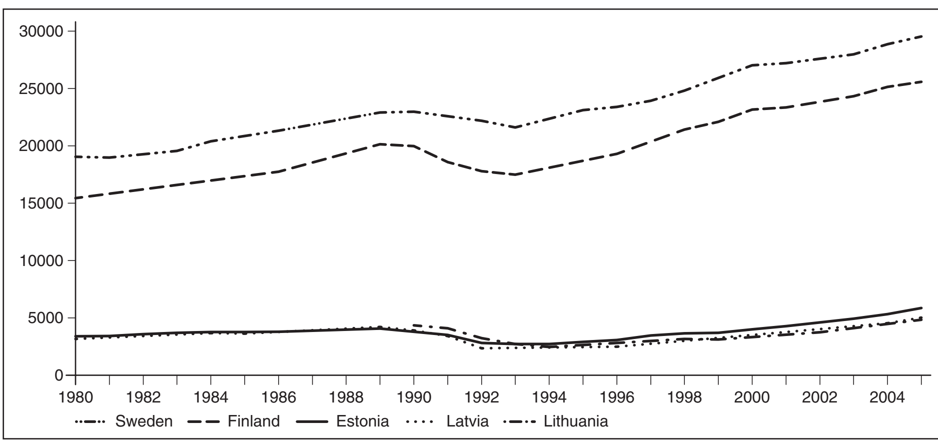
2 – See Reinert and Kattel 2004. For Estonia-specific issues, see Kattel and Kalvet 2006; Kalvet 2006; Tiits, et al. 2006, 2003.

Figure 1. **Manufacturing value added per capita in the Baltic countries, Finland and Sweden, 1980-2000.**



Source: UNIDO Industrial Development Report 2004, Table A19; calculations by the authors.

Figure 2. **GDP per capita in the Baltic countries, Finland and Sweden, 1980-2000.**



Source: World Bank WDI online database; calculations by the authors.

3. Structural Funds in Support of Economic Development?

This phenomenon of de-industrialisation and primitivisation is not only common to Estonia, Latvia and Lithuania. In the last 15 years, politicians, policy makers and policy analysts in the Central and Eastern European states have experienced and learned to cope with an economic world in constant change and disequilibria around them. Yet, standard economics textbooks and much of international advice they have received, voice the opposite – the economy is bound to come to stability after the initial shocks and changes. Governments of new EU member states are told to leave the market alone as much as possible – market being, to paraphrase Churchill's phrase on democracy, the most effective amongst the generally ineffective ways to allocate scarce resources. However, these governments face on a daily basis situations and spheres of life in which there is almost no other actor but the state that could best address issues of science, education and health care, to name the most obvious ones. In textbook equilibrium economics these concerns are regarded as ‘exogenous forces’ – that is to say, outside the market.

It is not only Joseph Stiglitz, former chief economist at the World Bank and Nobel Prize Winner in economics in 2001, who has voiced heavy criticism against this kind of ideology represented by international organizations (Stiglitz 2001). It seems that also world economy is developing into a phase generally referred to as knowledge-based economy, a socio-economic framework where new knowledge is the key for future success. Thus, the formerly known exogenous factors have become the main players on the market. This has brought about hectic cries for drastically increased research and development (R&D) funding, both public and private. Ironically though, most of the governments in the Central and Eastern Europe have given away in the rush to liberalize their respective economies most of the policy instruments to do that. Obviously, in the long run this furthers these countries from the developed world, and endangers severely the relatively successful, but painful catching-up process of the 1990s. The Central and Eastern Europe, including the Baltic states, needs to be innovative on the policy level first of all.

Perhaps one of the most crucial elements lacking in economic policy-making in the new EU member states is the strategic dimension. Concentration on fiscal and monetary issues (balanced budgets and Euro requirements) has created a policy environment where annual plan dominates over strategic plans. A crucial exception to this general perception is the developments in the EU Structural Funds, which became available to the new member states since 2004. As funds are distributed according to country’s strategic plans negotiated with the European Commission, this process has brought strong strategic elements into policy-making. In countries like Estonia, structural funds and their regulations cover almost all innovation policy measures. The positive impacts of structural funds on the development of new member states are hard to underestimate, and there are a number of significant lessons to be drawn from the current funding programme for the period 2004-2006:

1) There is a lack of clear and strong priorities. Most policy documents regulating structural funds in the new member states tend to be rather general and cautious. Since structural funds are distributed through competitive projects, this has led to a policy environment in which significant amount of funds go to projects that do not necessarily contribute to socio-economic development.

2) In some instances EU structural money became a *substitute* to the lack funding for certain government activities – instead of it being merely an *additional* funding to these activities. This has severely diminished its potential to have a positive effect to socio-economic development.

3) The partnership based policy design of the EU Structural Funds – between the EU institutions as well as national authorities, on the one hand, and the new, poorer, member states, on the other – has almost been completely neglected. As a result, policy-making is often devoid of any feedback mechanism, which means that the government agencies in charge do not have a clear overview of the problems they need to solve.

4) Particularly in the field of innovation and R&D policies there has been a remarkable tendency to create policies that should ameliorate the so-called European paradox: good basic research but little commercialization thereof.

While this understanding is strongly based on the linear understanding of innovation (i.e. that there are few steps from basic research to innovative companies) that is not true for the "old" EU member states, it has been clearly harmful for the new member states. Existing (traditional) industries have been almost completely neglected in countries like Estonia.

Alongside the general macroeconomic framework the problems that have become apparent in the regulations of the structural funds regulations mean that in the Baltic States there is no coherent policy measures that are designed to address the core problem of these countries: low (industrial) productivity. For the new structural funding period these countries need to learn from their current experience on structural funds and the importance of strategic policy making. Particularly important areas are:

1) There is a need to focus on productivity. Different measures from various fields must be coordinated towards rising private sector productivity.

2) This also means that much in the current system of policy making need to be reconsidered. Policy-making requires efficient and effective feedback channels in which the development needs of the private sector are met. As such, economic and innovation policies need to have strong sector-specific elements.

4. Project History and Outline

The publication is based on two PRAXIS projects. The first of them – *Creative Destruction Management in Central and Eastern Europe: Meeting the Challenges of the Techno-Economic Paradigm Shift* – was originally called to analyse economic and social processes of the countries of Central and Eastern Europe (CEE) from the perspective of the Schumpeterian economic framework, and to propose policy recommendations. The idea of the project emerged in discussions with the Council of Europe (CoE), the main body in which both the members of the EU and the other European nations, including CEECs, were represented. In particular, members of the Economic Affairs Committee of the Council of Europe's Parliamentary Assembly (PACE), which is in charge of projects such as these, urged to undertake such a research.

In September 2000 the project team wrote a letter of concern, proposing such research, to Hon. Ivar Tallo, MP of Estonian Parliament, and member CoE's Parliamentary Assembly (PACE) and of the Economic Affairs Committee of the PACE (1999 – October 2001). In December 2000, Ivar Tallo and the secretary of the Economic Affairs Committee, on the basis of the letter by the project team, drafted a motion that requests PACE to investigate the problems. The *Motion for a resolution presented by Mr Tallo and others. Need to narrow the wealth gap between countries in central, eastern and south-eastern Europe* (Doc. 8974, 5 February 2001) was endorsed by 15 members of PACE, three of them heads of fractions, and also by the chairman of the Political Committee. The investigation question was found worthy, referred to the Economic Committee, which appointed Mr. Tallo as a rapporteur in 2001, who together with the secretarial office, started to work out the exact project schedule.

However, with the resigning of Ivar Tallo from the Estonian Parliament, and respectively from the Council of Europe, all official processes stopped as CoE lost its rapporteur. In spite of that, the project team continued the research and organised research seminars in Venice, Italy (January 2001 and January 2003), and Frankfurt, Germany (December

2002) with the participation of the following experts: Jürgen G. Backhaus, Leonardo Burlamaqui, Ha-Joon Chang, Wolfgang Drechsler, Tarmo Kalvet, Rainer Kattel, Jan Kregel, the late Sanjaya Lall, Lars Mjøset, Alfredo Novoa, Geoffrey Oldham, Erik S. Reinert, and Henning von Wistinghausen. The research and meetings were funded by a grant by Open Society Institute to the PRAXIS Center for Policy Studies. Chapter II of this book presents some of the findings that emerged during those meetings.

Being convinced about the validity of the framework elaborated as well as the good feedback on the Estonian case-study, we continued to analyse on-going developments from this perspective and were continuously looking for various ways to extend the scope via involving researchers from other countries. And, we are grateful to the *Phare Cross-Border Co-operation Programme* which approved our application *Creative Destruction Management in the Baltic Sea Area* in summer 2005 and enabled us to continue the research and meet several times over the one-year period to discuss most important research and policy challenges.

Next to the Estonian co-ordinator PRAXIS Center for Policy Studies (Tarmo Kalvet, project leader; Rainer Kattel, senior researcher, also Professor at the Tallinn University of Technology; Anne Jürgenson; Marek Tiits) our main partners in these discussions were Pekka Ylä-Anttila and Christopher Palmberg (The Research Institute of the Finnish Economy, ETLA, Finland), Per Högselius (Centre for Innovation, Research and Competence in the Learning Economy, CIRCLE, Lund University, Sweden), Tarmo Lemola and Kimmo Halme (Advansis Ltd, Finland), Alf Vanags (Baltic International Centre for Economic Policy Studies, BICEPS, Latvia), Robertas Jucevičius and Monika Kriaučionienė (Kaunas University of Technology, Lithuania). There were, of course, many others who contributed to our seminars, most notably Erik. S. Reinert (Tallinn University of Technology, Estonia, and the Other Canon Foundation, Norway), Charles Edquist and Cristina Chaminade (both CIRCLE, Lund University), Mark Knell (Norwegian Institute for Studies in Innovation, Research and Education, Centre for Innovation Research, NIFU STEP), Wolfgang Drechsler (Tallinn University of Technology), just to name some.

Over the life-span of the project the following seminars took place: *Technology Transfer and Innovation: General Evidence and the Case of Estonia* (Tallinn, October 2005), *Small States and Development Policies: Creative Destruction Management* (Lund, Sweden, January 2006), *European Union 2005 and the Lisbon Strategy: Europe's Economic Problems and Policy Responses* (Tallinn, Estonia, March 2006), and *Development Policies in the Baltic Sea Region Countries* (Tampere, Finland, March 2006). Final results were presented at the conference *Economic Development in the Baltic Sea Region: Challenges and Opportunities*, August 2006, Pedase, Estonia.

5. Introduction to the Book

It would be impossible to summarise all the discussions and research results within one book, and thus only selected topics discussed and papers produced are published. The major theme is: what are the issues governments face today and in the foreseeable future, and how to balance an (sometimes extremely) open economy with the demands of knowledge-based society. As this publication argues, innovative policy and institution building are one of the main features of capitalist economy due to the very nature of capitalist process, which is to incessantly develop further, to incessantly create new ways to earn money, and over longer periods to change the structure of the economy as a whole.

The book starts with a general discussion (chapter II) arguing that Creative Destruction Management (CDM), a term from the Schumpeterian economic framework, means that the innovation-based and financially scaffolded transition to new techno-economic paradigms necessarily destroys the old industries, their employment, financing, and related structures, but that this process can and must be managed by the state in order to maximize gains and minimize adverse side-effects. It was produced as a framework paper to analyse economic and social processes of the countries of Central and Eastern Europe for the Council of Europe (see section 4 above). The chapter is authored by outstanding innovation scholars from various countries and continents, showing the world-wide relevance of the topic. Preparation of the framework paper was chaired by Wolfgang Drechsler, Tallinn University of Technology.

In the following chapter (III) Per Högselius is taking a closer look at the possible behaviour of national system of innovation when facing creative destruction. A process of creative destruction is seen to be initiated by a discontinuity in technology or politics, and the main question from a systems perspective is then whether the system's structure and style can respond to the transformation challenge. In our rapidly globalising era, the importance of understanding national systems of innovation in relation to their foreign environments is clearly increasing. And thus circumstances under which small national systems of innovation have their greatest chance to effectively adapt to radical changes abroad will is analysed.

Another highly relevant topic is raised by Christopher Palmberg and Tuomo Nikulainen who are discussing the importance of nanotechnology and its perceived, and partly also over-hyped, generic nature and potentials to renew industries in a revolutionary way (Chapter IV). Authors argue that the field is still in a fluid and uncertain phase without clear indications of how and where commercial breakthroughs will emerge on a larger scale. This paper discusses to what degree nanotechnology fits the criteria of a general purpose technology as many claim, reviews the extant empirical research towards this end, and provides a brief overview and new insights into the development of nanotechnology in Finland.

In another contribution by Per Högselius (Chapter V) it argues that the capitalist systems of production provides a fascinating and dynamic but at the same time highly problematic method of bringing about socioeconomic change. Capitalist systems tend to produce a variety of goods and services that are successfully marketed and sold, but which are in reality not always very useful to people and organisations and which in many cases may bring more harm and unhappiness than positive effects. And even when they do not bring explicit harm and unhappiness, many products appear questionable because they are often vastly inferior in their functions and quality to existing and price worthy alternatives – alternatives that for one or the other reason do not manage to reach out to the users. The article looks at the creative destruction of banking technologies, old-generation nuclear power stations, copper-wire telephone lines and fossil-fuel energy production.

In chapter VI Tarmo Lemola and Pekka Ylä-Anttila analyse the evolution of Finnish science and technology policy from mid-1960s until recent days. Special emphasis is laid on developments since early 1990s. In a less than a decade the country became one of the leading information societies and knowledge-based economies in the world. The resurgence from the deep recession of the early 1990s is in considerable part attributable to the developments in the information and communications technology (ICT) sector. Particular research topic here is how Finland became a success story in ICT. The basic argument of the paper is that a 'Finnish model' of information society or science and technology policy was not created in the years of rapid growth of the 1990s. There was no ‘master plan’ prepared in the early nineties to restructure the Finnish economy. The success came rather as a result of a series of policy measures over a longer period. They were working in the same direction and produced effect partly in the 1990s. There were also complementarities between policies, financial market liberalisation, and legal restructuring. Hence, as a society, Finland was relatively well positioned when the opportunity came.

Finally, chapter VII by Marek Tiits reviews the dynamics of economic development in the Baltic Sea region since the 1990s. It can be noticed that both the public policy responses and the outcomes varied significantly. While the Nordic countries employed rather pro-active approaches for upgrading the existing competitive assets, the Baltic States, Poland and Russia focused predominantly on the stabilisation of the macroeconomic framework, paying relatively little attention to the actual capability of the industry to cope with rapid changes. As could be easily expected from a common-sense point of view, these developments led to the strengthening of the industry in the Nordic countries and to the demolition of a large part of inherited, although largely uncompetitive, industries in the Baltic States as in the majority of the rest of the former Soviet bloc.

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II. CREATIVE DESTRUCTION MANAGEMENT IN CENTRAL AND EASTERN EUROPE: MEETING THE CHALLENGES OF THE TECHNO-ECONOMIC PARADIGM SHIFT [1]

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Abstract

Creative Destruction Management is a term from the Schumpeterian economic framework. It means that the innovation-based and financially scaffolded transition to new techno-economic paradigms necessarily destroys the old industries, their employment, financing, and related structures, but that this process can and must be managed by the state in order to maximize gains and minimize adverse side-effects. The processes of creative destruction can go either way: there can be creative destruction and there can be wasteful destruction. In order to avoid the latter, governments in Central and Eastern Europe need to be innovative on the policy level, and some focus areas where such innovative policy measures are most needed, are introduced. As argued, such kind policy adoption in not only historical normalcy, but rather a prerequisite of the development of capitalist economy as such.

1. Theoretical Framework

1.1. Schumpeterian Economics

The economy is an interdependent sequence of dynamic forces of change and static equilibrating forces. According to Joseph A. Schumpeter, a static general equilibrium may be used to explain the determination of prices under a circular flow economy, but innovations, engined by financial system, move the entire system in a new direction (Schumpeter 1939). An innovation is the use of a discovery or invention, or of a newly discovered or invented combination or use of known

1 – The main thesis of the publication were prepared for the Council of Europe in 2000 and 2001.

items or processes, within the economy, so as to create an economic advantage – ideally a short-term monopoly. Innovations are produced by entrepreneurs, whose motives however are more complex than profit maximization.

As Schumpeter puts it, this is the "industrial mutation – if I may use the biological term – that incessantly revolutionizes the economic structure from within, incessantly destroying the old one, incessantly creating a new one. This process of Creative Destruction is the essential fact about capitalism" (Schumpeter 1950, 83). Economic growth, unlike economic development, denotes the slow, gradual and cumulative (incremental) change of an economic system, resulting from factors, such as population growth, which can be argued to stem from sources that are exogenous to the economic system. Economic evolution or economic development, on the other hand, is driven by innovation and its economic effects (Schumpeter 1939, 58-61). The Schumpeterian approach is chosen here, first of all, because it deals with the problems brought out by the analysis of economic development. It also enables to analyze economic systems with relatively high growth numbers, yet with rather lagging development, like CEE countries (CEECs).[2]

1.2. Innovations and the Techno-Economic Paradigm Shift

Christopher Freeman (1994) has proposed a widely used taxonomy of innovations:

1) *incremental innovations*: gradual improvements of the existing array of products, processes, organizations and systems of production, distribution and communication;

2) *radical or basic innovations*: a discontinuity in products, processes, organizations and systems of production, distribution and communication, i.e. a departure from incremental improvement, involving a new factory, market, or organization;

3) *new technology systems* ("constellations of innovations"): economically and technically inter-related clusters of innovations (radical and incremental);

4) *technological revolution* ("change of techno-economic Paradigm"): a pervasive combination of system innovations affecting the entire economy and the typical "common-sense" for designers and managers in most or all industries.

According to this view, similarly to scientific paradigms, there are also technological paradigms (technological research programmes) that determine the technological problems, the scientific principles and material technologies to be used. Each paradigm is characterized by technological trajectories (clusters of possible technological directions) that have some common elements such as an ordered, cumulative process of technical change by which a given technology tends to move towards its highest possible level of efficiency. Particular economic and social contexts create selection environments which establish a trajectory of innovations. These, in turn, facilitate broad financial innovations, organizational and management change, and new patterns of consumption.

Once a dominant pattern – a new common sense – is established, there is a period of broad stability in which the innovation process conforms to a common set of criteria, and the design of technological artifacts changes in an incremental, evolutionary manner (Dosi 1982 and 1988). In order to bring along a techno-economic paradigm change, the radical

2 – Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Estonia, FYR Macedonia, Hungary, Latvia, Lithuania, Poland, Romania, the Slovak Republic, and Slovenia.

innovations together with incremental innovations give rise to new technology systems, fueled by financial sector, and affecting the entire economy.

Although the former technology is physically as productive as before, its relative attractiveness is seriously diminished because of the much larger profit opportunities arising in the new paradigm carrying industries. The financial effect of these paradigm changes is that it is simply not lucrative anymore to invest in "old economy" fields, which means that capital is siphoned out of them, even if "as such" they would still be productive. The social effect includes the creation of demand for new labor- and educational structures, and the dismantling of the old ones, as well as changes in key social and cultural patterns of life (e.g. urbanization, mobility, networks). This also challenges the basis of the political sphere, in that changed participatory structures transform the political cohesion of a community.

Thus, in order to fully deploy the enormous wealth-creating potential brought about by a new techno-economic paradigm, establishment of an adequate socio-institutional framework is required. The existing framework, created and evolved to handle development and growth based on the previous paradigm and its set of technologies, cannot handle the new one.

These techno-economic paradigm shifts have occurred in waves or cycles, named after the Russian economist Kondratjev who discovered them. This has been developed further by Schumpeter, Freeman, and in particular by Carlota Perez (2002, 1985 and 1983) and has become to be known as the Schumpeter-Perez-Freeman thesis (Arthur 2002).

This thesis holds that since the 1780s, there have been four complete surges or cycles, with an upswing of the "Fifth Kondratjev" in the 1990s. All waves were based on key technological innovations (like cotton, coal and iron, steel, oil and plastics) that fulfill, according to Perez, the following criteria:

1) clearly perceived low and diminishing costs;

2) a supply, which for all practical purposes, is unlimited;

3) potential for all-pervasive influence in the productive sphere, and

4) a capacity, based on a set of interwoven technical and organizational innovations, to reduce costs and change the quality of capital equipment, labor, and products (Perez 2002).

These bring, in turn, about the adoption of the socio-economic context to the new technology system through 1) developing the surrounding services, the required infrastructure, specialized suppliers, distributors, maintenance services, etc.; 2) "cultural" adaptation to the logic of the interconnected technologies involved (among engineers, managers, financiers, sales and service people, consumers, etc.); 3) setting up of the institutional facilitators (rules and regulations, specialized training and education, etc.). This, in sum, creates major territorial advantages.

And thus enterprises that carry out the techno-economic paradigm shift tend to be organized as clusters or development blocks. Clusters are networks of production of strongly interdependent firms and other institutions such as research labs and universities linked to each other in a value-adding production chain. They play a significant role as geographically concentrated competition domains, where shared infrastructure, complementary expertise and business activities alongside with highly complex competition-relationships generate synergy in the form of higher productivity, know-how spill-over and innovative incentives (Porter 1990).

However, clusters or development blocks depend largely on a wider institutional framework, ranging from infrastructure to availability of financial capital. These are called systems of innovation. According to a widely held approach, these consist of the elements and relationships which interact in the production, diffusion and use of new, and economically useful, knowledge and that a system encompasses elements and relationships, either located within or rooted inside the borders of a nation state or its regions (Lundvall 1995). Thus, a system of innovation covers next to organizations also rules, norms, habits, and shared expectations that pattern economic behavior.

Still, there is no such thing as a generic system of innovation; these institutional frameworks are always unique and country-specific depending very strongly on general and specific political-economic situation and policies. This means that on the political and policy level it is of utmost importance to understand specificities of the system of innovation currently at place as well as its standing in terms of techno-economic paradigms relative to world economy. Different stages of techno-economic paradigms and theirs shifts demand thoroughly different policies to keep or get a system of innovation running (Perez 2001). Arguably, this is one of the most important and interesting questions policy makers are facing today. As different technologies and paradigms require entirely different sets of policy measures, the answer to this question, and specifically for a given country, will decide the sustainability of economic development and prosperity more than almost anything else.

1.3. The Current Techno-Economic Paradigm Leaders

The current paradigm, similar to earlier ones, is also described by the dominance of some key technologies. Central to the emergence of the on-going technological paradigm, based on information and communication technologies (ICT), was the discovery of the transistor in 1947. During the 1960s and 1970s, the rapid development of semiconductors took place, which are the "building blocks" of microprocessors, microcontrollers and memory chips, and in the post-war electronics industry, transistors and then integrated circuits were an enabling technology for most technological innovations (Kenney and Burg 1999). Currently, "even those who have disputed the revolutionary character of earlier waves of technical change often have little difficulty in accepting that a vast technological revolution is now taking place, based on the electronic computer, software, microelectronics, the Internet, and mobile telephones" (Freeman and Louçã 2001, 301).

In spite of the fact that ICT has already found its place in different applications, it continuously plays a central position in technological innovation. Different studies focus on the concept of Ambient Intelligence (AmI), the situation of humans being surrounded by intelligent interfaces supported by computing and networking technology. This stems from 1) the convergence of ubiquitous computing and communication (computer-based devices, due to their low price, interoperability and ease to use are applied across a broad range of technologies), and 2) intelligent user friendly interfaces (Riva *et al.* 2005).

In the context of the Fifth Kondratjev, next to ICT, "new or modern biotechnology" or "third-generation biotechnology" (usually referred to simply as biotechnology), the use of the cellular and molecular processes in production, has been often considered as the (second) key factor of the Fifth Kondratjev. Its most important part, genetic engineering, involves the manipulation of the genetic code of organisms. The authors, however, agree with Perez who argues that

> *biotechnology, bioelectronics and nanotechnology might conform the next technological revolution. Indeed, they are already developing intensely within the logic of the information society. They seem to be at a stage equivalent to the oil industry and the automobile at the end of the 19th century or to electronics in the 1940s and 50s, with valve-TV, radar and analog control equipment and telecommunications. The key breakthrough that would make it cheap to harness the forces of life and the power hidden in the infinitely small is still unpredictable* (Perez 2002).

This way, biotechnology can potentially create entirely new spheres of economic activity, necessarily destroying the existing ways of production and management, and more importantly, the social structures tied to these. However, biotechnology is by its very nature a field of activity under strict governmental regulatory mechanisms; its development and dissemination, i.e. the innovative impact on economy, is strongly affected by legislative and policy solutions. It may be possible to reach international agreements which will control the more aggressive developments of human genetic technology; however, in any case, the role of the state in innovation and creative destruction will be stronger than ever before.

According to the Freeman's taxonomy of innovations mentioned above, these technologies continuously form new technology systems and cause a discontinuity in products, processes, organizations and systems of production, distribution and communication. However, technological innovation can only occur if there are a set of pre-requisites fulfilled. Without these and many other resources and activities, innovation would not appear: "Innovation is possible without anything we should identify as invention and invention does not necessarily induce innovation, but produces of itself no economically relevant effect at all" (Schumpeter 1939, 59).

1.4. Creative Destruction Management as the Role of the State

One of the main tasks of the state according to the Schumpeterian framework is to face, analyze and meet the predictable challenges created by Creative Destruction – preferably through measures other than regulation –, so that those who are the victims of this process become integrated into the new paradigm or are taken care of in an optimal way. This approach allows for social policy that neither is nor looks harmful for economic development and innovation, and thus does not fight but rather supports the paradigm shift. Because this is a task of CDM as well: To facilitate the meeting of the new paradigm on the part of the state and its economy, rather than fight it, through appropriate and enlightened industrial, fiscal, educational, and general economic policy.

The Schumpeterian concept of creative destruction emphasizes the importance of destroying in order to build something new and better. In this process, some people will necessarily suffer as a consequence of the destruction, but the overall process of replacing the obsolete by something new creates so many new opportunities that every loser can in principle be well compensated through the new initiative. Yet, one of the most important lessons from the history of capitalism is that markets when left alone, do not provide a positive outcome here. As Hyman Minsky argues,

Capitalism evolves and so too must the legislated institutional structure. The evolution of the private sector's institutional structure is market driven – driven by agents acting in their own self interest. This evolution can undermine the barriers to instability and inefficiency. Such undermining has to be offset from time to time by changes in the government's institutional structure. These dynamic institutional changes preserve the dynamic efficiency of capitalism (1996, 33).

In the process of creative destruction, the economy always exercises an increasing pressure on the state as well as on societal structures of human living-together, upon which the economy, however, itself rests. This means that these social structures increasingly fall under the influence of profit maximization, and thus are less and less able to deal with the consequences of creative destruction and economic development. The need of social development is therefore not defined by economic means or categories, but through and by state and democratic structures of governance, emphasizing, e.g., stronger participatory elements and structures in local government as well as in labor market policies. In short, managing creative destruction and techno-economic paradigms demands also changes in the political structure of the state.

Thus, it is important to note that the processes of creative destruction can go either way: there can be creative destruction and there can be wasteful destruction. Hence, processes of creative destruction need *stewardship*; they need to be well managed; there has to be a framework in which they can take place. So far, the only institution that can provide both management and framework is the state.

2. Creative Destruction Management and Central and Eastern Europe: General Overview

The Schumpeterian creative destruction - destroying in order to build something new and better - is a process taking place also in societies not undergoing deep change. However, it is all the stronger in Central and Eastern Europe (CEE). Here the transformation since the Fall of the Wall presents additional, specific problems that are different from those in the other parts of Europe and indeed of the world. In addition to the (re)establishment of political and economic independence and the transition from planned to market economy, these countries are experiencing the transition to a new techno-economic paradigm *as well*.

Usually, move to market economy followed the neo-liberal “laissez faire” approach described by heavy reliance on market mechanisms, “getting the state out of the economy”, rapid and large-scale privatization, free trade, and liberal investments laws.

Thus, the exposure of the CEECs to creative destruction is not only a phenomenon rooted in the processes of transition from planned to free-market economy. According to Joseph Stiglitz, the framework created for this transition, by the new political elites and the various organizations of international advisorship and help, was heavily tilted towards financial capitalism preaching the Free Market as the Archimedean point of a new utopian project of social engineering – much the same way in which Communism was preached decades before (Stiglitz 2001).

Most of the CEECs inherited a huge - but structurally distorted - industrial sector from the period of central planning and during the transition period the process of deindustrialization followed. Also, the problems of restructuring of R&D and innovation activities were treated as marginal, characterized by “gradualism without therapy“ and in some cases even as “shock without therapy” approaches (Radoševic 1999). This way, a lot of R&D supply channels as well as absorptive capacities were lost, and the major agent for economic restructuring has been foreign direct investment (FDI) driven inward technology transfer, that is technological upgrading. This has resulted in the process of productivity increase as catching up (an approach initiated by Abramovitz 1986) – relatively backward countries are easily able to grow faster than advanced countries, because of their ability to imitate technological knowledge, and hence converge to the frontier value of per-capita income more rapidly – and brought relatively good indicators of economic growth. This development as been largerly dependent on FDI. However, as research results for some CEECs indicate, FDI do not generate positive intra-industry spillovers for domestic firms, and for some transition countries FDI were found to have significant crowding-out effects for local firms in the same industry (Damijan *et al.* 2003). Thus, as studies emphasize, most FDI coming to CEE has been market seeking rather than representing an attempt to integrate CEE production into EU production networks (see, for example Barry 2002).

However, radical opening of markets and the specific quality of FDI, has lead to peripheralization of much CEE industry, meaning that productivity increase takes place in some sectors only without spilling over to others. These leading sectors, in turn, tend to be mainly low-tech, labor-intensive and low-wage industries relying on economies of scale and continuing FDI.

This similar pattern seems to also emerging in current paradigm-leading industry, namely ICT. As evidence from Estonia shows, ICT sector follows suit in relying on FDI as well as on subcontracting activities i.e. not knowledge- and R&D-intensive activities (Kattel and Kalvet 2006; Kalvet 2004).

Thus, although the CEECs, most notably the leading four (Estonia, Slovenia, Czech Republic, Hungary), have experienced quite extensive and successful catch-up process (Piech and Radosevic 2006), this process itself seems to rely on methods and measures characteristic of *previous* level of development, i.e. previous techno-economic paradigm, which can be called "Fordism". These characteristics include heavy reliance on "cheap" FDI, technologies of mass production and assembly-line supported by the fact the main bulk of innovations are in effect upgrading of old and inefficient machinery, followed by mass consumerism and financial innovations supporting low- and medium-technology sectors and their imports as well as mass consumption. Thus, the catching up process is largely confounded to a very specific point in time, 1990s, and cannot be hoped to remain as intense as it has been.

Thus, since the collapse of the Soviet system, the CEECs have specialized in low-tech, labor-intensive, low-wage industries, meaning that they tend to become locked-in in low- and medium-technology sectors (Stephan 2003). Such a process, however, is dangerous in the long run as it can make the so-far relatively successful catch-up process and policies supporting it obsolete and counter-productive, and most importantly, it will not help to solve the problems related to social sphere like unemployment, underemployment and poverty. The opposite might come true.

3. Creative Destruction Management in Central and Eastern Europe: Focus Areas

In order to be successful at creative destruction management it is, however, not enough to copy established Western policies; context specificity demands also appropriate policy measures as well as a serious and reliable evaluation of the current state of affairs. Moreover, CEECs have clearly reached the point where there is a clear need for turn-around in the previous R&D and innovation policies. It cannot be expected that CEECs will give up the reached and politically sought for levels of liberalization and openness. But, the need to very innovative on the policy level, is very strong. The need for the transformation of the role of the government with changing economic conditions and development is needed (Mrak 2000).

The following section of this article brings out six focus areas where such innovative policy measures are most needed. However, these sections intend also to show that this kind policy adoption in not only historical normalcy, but rather a prerequisite of the development of capitalist economy as such.

3.1. Socialization of Risk

Throughout the history of capitalism, a range of institutions that protect individuals from bearing the full consequences of their actions have been developed in order to *encourage risk-taking and innovation*. The most obvious examples from history include institutions like corporate limited liability, central banking (and other lender-of-last-resort facilities), insurance, the underwriting of risky ventures by the government (especially, but not only, in late-developing countries), a patent system, and the protection of other intellectual property rights.

Predictably, these institutions have been accused of encouraging “irresponsible” behavior by severing the link between economic agents’ actions and their responsibilities – or of creating “moral hazard”, in modern economic jargon. This sentiment is best summed up in the remark by Herbert Spencer when he voiced his opposition to the development of lender-of-last-resort facilities, arguing that the “ultimate result of shielding man from the effects of folly is to people the world with fools” (quoted in Kindleberger 1996, 146).

However, these *institutions to socialize risk* have been a key to the success of capitalism. According to Nathan Rosenberg, the “history of capitalism involved the progressive introduction of a number of institutional devices that facilitated the commitment of resources to the innovation process by reducing or placing limitations upon risk while, at the same time, holding out the prospect of large financial rewards to the successful innovator” (Rosenberg 1994, 96).

Since the late 19th century, building institutions to socialize the risk for the workers became a key to the management of the process of CDM, as the workers began to acquire the power to block the process of innovation through industrial and political actions. Between the late 19th century and the Second World War, most Western European countries established social welfare institutions – including industrial accident insurance, pensions, health insurance, and unemployment insurance – in order to diffuse revolutionary tensions in their societies.

After World War II, institutions to socialize risk for the workers developed further. The Scandinavian countries complemented their generous unemployment benefit systems with active labor market policy, which helped the re-training and re-location of workers. Japan did not have social welfare institutions of similar quality, but lifetime employment for the core workers made it possible for their firms to introduce new technologies aggressively without too much resistance from the workers.

As a result, throughout the post-war period, societies that were better at socializing risk for the workers proved better able to introduce new technologies, as their workers were more willing to accept job changes and temporary redundancies involved in the process. It is no coincidence that Japan and Sweden are two of the most robotized economies in the world – they were both good at making their workers accept new technologies by reducing the risk that they faced in the process, albeit through very different institutional mechanisms.

In conclusion, the management of the process of creative destruction requires a process of building institutions that can use the gains to socialize the losses, both for the entrepreneurs and for the workers, in a way that encourages innovation but minimizes the potential for moral hazard.

CEECs has so far done almost exactly the opposite: radical liberalization and high unemployment are accepted as transitions costs, accompanied by low investment in R&D and technological catching-up dissemination activities, by an overall framework enforcing sub-contracting and retail activities, and by weak labor market policies and unions. All this has strengthened, rather than decreased, the negative effects of transition.

Moreover, as George Soros (2002) argues in his Report on Globalization, liberalized financial markets often bring new wealth and investments without any national or international structure to deal with the results of creative destruction. This means that there is no globalized mechanism to socialize the losses. Moreover, the policies of the International Monetary Fund (IMF) and World Bank (WB) have so far demanded the liberalization of markets, thus even more reinforcing the "destructive" side of the creative destruction process and at the same time making respective governments unable to more forcefully deal with these results. As Soros argues, this brings about a need to reform the international monetary framework in favor of structures and possibilities to really deal with the effects of creative destruction and development.

3.2. Entrepreneurship and Fiscal Responsibility

In principle, creative destruction needs the *removal of entry barriers* for entrepreneurs in both markets and those networks and organizations of which society consists and which provide the general framework in which market activity can take place. Removal of barriers to new initiatives immediately has its counterpart in the requirement that creative destruction has to provide for something new and better. Hence, if creative destruction is a case of mere rent-seeking, with no compensatory benefit for society as a whole, the destroyer needs to face liability. Thus, with the access to the market so as to make possible creative destruction, there must be a liability that the entrepreneur faces. Processes of transition open opportunities for creative destruction that are mere rent-seeking, but they also open venues for creative destruction so as to create new rents, of which the successful entrepreneur should appropriate a part as its incentive. Stewardship of creative destruction must precisely steer entrepreneurs into rent creation while at the same time imposing punitive sanctions on mere rent-seeking. Such stewardship is difficult to organize, especially as it should be self-enforcing.

In general, the state can achieve any effect it desires by imposing either taxation or regulation. However, typically, the costs of regulation are not accounted for. Yet, they can be so high as to consist in the dissipation of the cultural heritage, the diminution of life chances and in massive disinvestments in both public and private property. In processes of transition, most governments are likely to revert to regulation instead of taxation, since the costs of regulation are not showing up in the budget. Stewardship of creative destruction, however, requires showing the total extent of the harm imposed by the destruction, as the compensatory creation of rents needs to by far exceed the cost imposed. Such stewardship will require institutions which have the role to assess initiatives in terms of weighing destruction and creation against each other.

3.3. Industrial Policy and Activity-Specificity

History tells us that the creative and the destructive aspects of creative destruction may take place in different geographical areas. The opening up of the CEECs to international trade led to a Vanek/Reinert effect, i.e. when free trade is opened between a technologically advanced and a less advanced country, the first economic casualties – the first economic activities to close – are the most advanced activities in the least advanced nation (Reinert 1980). The computer industry in former Czechoslovakia is a case in point. In other words, as producers, the CEECs largely missed out on the first round of effects of the paradigm shift.

The last 10 years of transition in the CEECs have brought changes in the economic structure and social problems which are similar to those observed as the effects of the Morgenthau Plan after World War II (Reinert 2003). Many of the social problems are a result of the loss of jobs in the secondary sector, the sector where the economic activities are found that are subject to increasing returns to scale. Recent research points to the close connections between increasing return activities and high level of GDP per capita.

In a Schumpeterian world, it is possible for a nation to have a comparative advantage in being poor and uneducated, producing goods which require little skills at a very low wage level. However, at any point in time, different economic activities offer different windows of opportunity for use of new knowledge, education and training. During the transition from the use of kerosene lamps to the use of electrical light, a nation stuck with a comparative advantage in the production of kerosene lamps would have had very poor possibilities to invest profitably in training and education in their special area. The demand for training and education in a nation is consequently *activity-specific*; it varies according to the sector in which the nation has created its comparative advantage. This priority-setting, however, cannot be left to the market, it is the task of the government.

For this reason, traditional industrial policies by European governments have for centuries attempted to distribute the production of economic activities with a high potential for learning – the 'new paradigm' industries – to their respective nations. The 1980's and 1990's represented a break in this policy, and the Neoclassical economic theory, where all economic activities were seen as qualitatively equal in terms of providing economic growth, came to dominate. Efficient CDM requires the traditional activity-specific element in economic growth policy to be re-introduced.

An important challenge to the CEECs is to devise institutions and mechanisms which make it possible for the productive structures of these nations to benefit from the use of new technology in increasing return activities. History shows that there is an important connection between the size of the increasing returns sector in the economy and the level of real wages and the level of employment. From this point of view, social problems – their causes rather than their symptoms – may be pro-actively addressed by strengthening the productive sector of the nation and by changing its composition. This means rebuilding social capital via mechanism that support small and medium-sized firms, shortening agency chains to improve corporate governance, and strong labor participation in decision-making processes

3.4. Financial Issues

The impact of the financial system on the process of innovation taking place in the productive sectors of the economy can only be understood by reference to the balance sheets of corporations, financial institutions and households. The productive assets and working capital balances of the business sector are financed by loans that appear on bank balance sheets and financial assets that appear on household balance sheets. The banks finance these loan assets by issuing their own liabilities, such as call and time deposits, while households finance their holding of these deposits and the liabilities of firms through the excess their incomes over expenditures.

If the financial system is to support innovation it must be able to allocate the power to command resources to those firms who will use them to make the highest contribution to well-being by allowing them to create liabilities which are initially held by the bank as assets in their loan books. If the innovation is successful the firm will be able to meet its payment commitments in a time manner and repay the principal of the loan with an excess remaining which represents the entrepreneur's profit.

However, the fruits of investment in a new innovation are in the future and the ability of the firm to repay the bank loan in a timely manner is always highly uncertain when the loan is made. Banks frequently look to the past credit history of the borrower or require a claim on land, real estate, or equity in an operation as collateral for their loans to reduce the risk of non payment. When banks make lending decisions in this way, loans are not allocated to the most innovative entrepreneurs, but to those who have a good credit history or who have had past successes which have allowed them to accumulate wealth to use as collateral. They may not be those who are seeking to invest in the new pattern of innovation which is by definition untried. Thus for the financial system to properly support the process of innovation mechanisms will be required to provide innovating entrepreneurs with guarantees or other forms of collateral which allows banks to finance investment on the basis of the future prospects of their investments in technology. This may be done by the state, either through its own investments or by providing guarantees, or by creating incentives for individual investors to bear part of the risks of investing in new technologies.

Major disruptions of the operation of the financial system in support of innovation occur when there are asymmetrical shocks to assets and liabilities. Creative destruction and transition from one type of economic organization to another are examples of shocks that reduce the financial value of productive assets while allowing the liabilities to remain on the balance sheets of financial institutions. Small differences can be met from the income, reserves, or capital of the banks. However, a large reduction in asset values may impair bank liabilities which households hold on their balance sheets as assets and thus reduce households' net wealth.

If financial institutions require corporations to meet their liabilities in full in order to avoid these losses, the process of supporting innovative activity will be compromised since firms will now be using resources to repay debt, rather than to innovate. Means must thus be found to offset the loss of asset values caused by creative destruction. This will usually require intervention by the monetary authority or by the state to offset the losses.

An example of how this might be done is given by the transition economies that may be considered to be suffering from creative destruction brought about by the introduction of an innovation in economic organization, market exchange, in a planned environment. Since most planned systems did not require a formal financial system, liabilities were not supposed to exist. Funds allocated to enterprises to pay workers' wages should have been just sufficient to purchase the consumption goods that had been produced at the plan prices, leaving no surplus in household accounts and thus no assets on household balance sheets. It was the failure of the planners to design and produce goods that consumers desired that led to a build-up of unspent wages which the households held as assets in state banks. These sums represented the so-called inflationary overhang. In the transition, when the values of the assets of state-owned enterprises collapsed on exposure to competition from market production these liabilities remained on the banks' balance sheets. Under normal market circumstances, if the nominal value of the assets falls below the value of the liabilities the enterprise is insolvent and must cease operations. The financial management of creative destruction required that the value of these liabilities be preserved even though the corresponding assets were devalued if households were to survive the transition without loss of wealth and if sufficient liquidity was to be maintained. But, every balance sheet requires that assets equal liabilities, so some compensation had to be made on bank balance sheets to keep them solvent and to avoid the loss of household wealth. This problem has been faced twice in Germany: After World War II and during Reunification. Both times it was resolved by the creation of special government debt instruments, *"Ausgleichsforderungen"*, which allowed the "equilibration" of bank balance sheets and provided the institutions with income to remunerate their "assetless" liabilities.

A similar problem was faced in the aftermath of the Southern Cone debt crisis when Brady bonds were created to provide a counterpart to the writing-down of the assets against which developed country banks had made loans. In the Brady scheme Indebted countries used their remaining foreign assets to buy zero coupon US government discount bonds (since the accumulated interest was paid at maturity the bonds sold at a discount, with the interest represented by the discount of the purchase price from the redemption value at maturity). Against this collateral the debtor could then issue special fixed interest coupon bonds of a similar maturity (named after the US Treasury Secretary Nicholas Brady) with a total value equal to the (higher) maturity value of the bonds, thus raising an amount of new assets equal to the difference between the discounted present value of the zero coupon government bonds (which had been bought with existing foreign exchange reserves) and the redemption value of the bonds. The maturing government bonds could then be used to repay the Brady bonds at maturity. The Brady bonds could then be exchanged for the devalued bank loans or sold and the proceeds used to repay outstanding loans.

Amongst CEECs, Bulgaria and Poland have both used Brady bonds in restructuring their respective foreign commercial debt (both issued them in 1994, US$ 5 and US$ 6 billions respectively). While the specific details of Brady bond packages have differed according to country circumstances, they have largely followed the structure laid down by Mexico in 1990. Negotiations have normally proceeded in tandem with a country's discussions with the IMF or other multilateral institutions. The role of the IMF has been to advise the respective governments regarding economic policy in order to ensure that its economy is "healthy" and thus able to meet its payment commitments by the time of the restructuring. The necessity to concentrate on repaying assetless liabilities diverts the productive sector from pursuing new innovations and thus diminishes the efficiency of the programme to provide creative destruction management.

The management of creative destruction as experienced in transition economies would involve financial engineering which would allow for the balanced creation of new assets and the destruction of old liabilities in a way that preserves collateral and encourages the financial system to create new assets and liabilities. According to the rules of capitalization, it is the present value based on the expected future creation of values that should be the determinant, not the current values reflecting the past destruction. Management of the financial system requires ensuring that it is the future, rather than past, values that are reflected in the current ones.

But when a shock such as creative destruction is present in the system, assets will have been destroyed, so that there is little available collateral and banks are hesitant to lend in a climate of failure. It is thus important, in managing creative destruction, to ensure that assets are preserved that may serve as collateral for bank lending to initiate the process of creation of new wealth. But this is not the only problem, for during transition, banks themselves will not have assets or capital to back their own liabilities. Thus, both the financial system, and the productive sector will require capitalization support from the state to provide for collateral necessary to allow the financing system to support the beneficial creation that will offset the destruction of asset values that has been caused.

3.5. Research and Development, Education, Training

Developing countries, including the CEECs, face two basic tasks in this respect: on the one hand, mastering and disseminating existing technology and skill, and on the other, creating innovative ones. Thus, there is the need for the supply and demand of training and education to be addressed simultaneously. Training and education in a special field must be accompanied by industrial policies that target and nurture the sectors demanding these same skills. The US regional policy, administered by the Department of Commerce, of creating growth clusters in every federal state is an example of a very good policy in this regard. A training and educational policy which fails to consider the demand side of the equation tends to just strengthen brain drain.

In CEE, the demand side has so far been ignored, and the transition has left important segments of the educational system useless as far as the labor market is concerned. These challenges could be met by the state with the establishment of technical high-schools (e.g., Germany, successfully copied by Japan and Korea); the introduction of a skill certification system (e.g., again Germany, and also used in Denmark and some other European countries as well as Korea); the strengthening of industrial training and re-training (both external and on-the-job); and perhaps also – although this needs to be discussed carefully – state subsidies to labor re-location via an active labor market policy (e.g., re-training, housing loans, etc.); and the introduction of manpower planning (successfully practiced in Korea, for example).

In addition, innovative economic activity in CEE is usually sought without a proper framework and without any co-ordination between science/education, industry, and government. The latter often leads to preferring low-value-added segments of the high-tech industry which do not require a high R&D intensity. In turn, this fosters the marginalization of basic science research and its capacities. The strong market pressure is not necessarily creating new knowledge, learning, or skill. In the Schumpeterian framework one can argue that some industries provide at any point in time larger windows of opportunities for innovations than others. If the innovations take place within the industry itself, rather than as purchased input, these industries tend to have higher concentration ratio than other industries. Some innovating firms can earn monopoly profits may, as a consequence, be better able to finance research and development for future innovations. This mechanism is an important part of the cumulative causation in successful market economy. In order for these cumulative processes to produce successful market outcomes, knowledge and learning have to be systematic and broad, based on co-operation between science, industry and government.

However, as Vannevar Bush put it in 1945 in his report to President Roosevelt, “Industry is generally inhibited by preconceived goals, by its own clearly defined standards, and by the constant pressure of commercial necessity. Satisfactory progress in basic science seldom occurs under conditions prevailing in the normal industrial laboratory. ... Basic research is a long-term process – it ceases to be basic if immediate results are expected on short-term support.” Basic research, inevitable for creating long-term capacity for sustainable growth and development, is not to be equaled with innovation. Basic research should be strongly supported via determining relative strengths in science. This should be accompanied by fostering domestic technology and knowledge-based transfer activities in the form of government policies.

In addition, educational policy is in CEE often seen as part of a larger national culture policy and thus may form much of the basis of the political consensus. It should be noted, however, that the logical mistake in combing this approach with an open free-market economy is never recognized by the respective policy makers. Even if this is politically profitable and viable, it necessarily creates – particularly in educational policy – two opposed policy-movers, leading often to confused and ineffective policies.

3.6. Social Policy

A major feature of the economies of CEE in the 1990's was de-industrialization, a heavy loss in the secondary sector of the economy. Many of the old industrial firms did not survive a sudden exposure to the world market, and unemployment resulted. There are important synergies between the secondary and both the primary and tertiary sectors, in the sense that a de-industrialization tends to reduce both the general wage-level and the general efficiency in the rest of the economy. As was observed in the United States in the 1930's, the industrial sector tends to create a ratchet wheel effect that makes real wage increases irreversible. Conversely, a sudden and large reduction of the secondary sector tends to make labor very cheap; i.e. it tends to increase poverty. In Schumpeterian terms, CEE has been asymmetrically exposed to creative destruction; a heavy load of destruction with a very limited countervailing creative part.

The "carrying capacity" of a nation in terms of population is traditionally tied to the size of the secondary sector. There is growing evidence from the Third World that the Social Funds so popular with international donors tend to treat the symptoms of poverty rather than to address its causes. These "safety nets" on a micro level, important as they are, are not a substitute for the macro level policies of the 1950's and 1960's, which were aimed at creating employment through industrial policy. To borrow a term from the medical profession, too much social policy is focused on "palliative economics", economics alleviating – but not curing – poverty, and in this way causing a long-term dependence on aid is created.

Nobel Laureate Arthur Lewis once observed that in many poor nations it seems as if the same total level of GDP would have been reached even if half the population would not have been there. The only long-tem way of solving the poverty problems resulting from this type of large-scale unemployment and underemployment is to re-integrate the poor into the national productive system by creating jobs. That, in turn, is a task of CDM.

These considerations notwithstanding, there is also an important space for traditional social policy. It needs to be handled unideologically, and with careful attention to the total social cost, and not just to the budget. This, calculating the costs for social programs on the level of the costs to the state or even larger community, rather than on the budget, will make it easier for many neo-liberal governments to accept such a need.

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III. NATIONAL SYSTEMS OF INNOVATION AND CREATIVE DESTRUCTION: A SMALL-COUNTRY PERSPECTIVE

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1. Introduction

In this chapter, the process of creative destruction and creative destruction management (CDM) is analyzed in relation to national systems of innovation.[1] The term 'system of innovation' has been around in academia and increasingly also in policymaking for about two decades by now and is thus far from new, but ironically and paradoxically, most research on national systems of innovation has been overly static and lacked any clear focus on the crucial processes of systems transformation and change. Taking inspiration from ideas developed by development economist Gunnar Myrdal, however, we will argue that the concept of national systems of innovation can indeed be used to better grasp the process of creative destruction and other radical transformation processes at the national level.

As we will see, it appears particularly fruitful to apply a systems of innovation perspective to the process of CDM in an area such as the Baltic Sea region, which includes not only large countries such as Germany and Russia, but above all a number of small states such as the Nordic and the Baltic countries. This is because a systems approach to innovation, by taking the concept of *system boundaries* seriously, has the potential to better grasp the interrelations between different national systems of innovation and hence put the small states of the region into their European and global context – a context that to an overwhelming extent defines both their threats and opportunities.

Abstract

The current article analyses how a national system of innovation can theoretically be expected to behave when facing creative destruction. A process of creative destruction is there seen to be initiated by a discontinuity in technology or politics, and the main question from a systems perspective is then whether the system's structure and style can respond to the transformation challenge. In our rapidly globalizing era, the importance of understanding national systems of innovation in relation to their foreign environments is clearly increasing. And thus circumstances under which small national systems of innovation have their greatest chance to effectively adapt to radical changes abroad will be analysed.

1 – This chapter builds in some parts on the theoretical part of my book The Dynamics of Innovation in Eastern Europe: Lessons from Estonia (Cheltenham, UK and Northampton, MA, USA: Edward Elgar Publishing, 2005).

The chapter is structured as follows. Section 2 describes the main building blocks of national system of innovation, discussing its typical components and relations between the components. This is seen to define the *structure* of the system. Section 3 goes on to define the system from a more dynamic perspective, focusing on the activities taking place in the system and the *style of innovation* that these can be seen to give rise to. Section 4 investigates the important issue of system boundaries, which can be thought of in somewhat different, though not necessarily conflicting ways. In section 5 we turn to the core of our interest, which is to understand how a national system of innovation can theoretically be expected to behave when facing creative destruction. A process of creative destruction is there seen to be initiated by a discontinuity in technology or politics, and the main question from a systems perspective is then whether the system's structure and style can respond to the transformation challenge. In section 6 we turn to a more particular discussion relating to the influence of foreign systems of innovation on domestic transformation, which leads us to a description of the circumstances under which small national systems of innovation have their greatest chance to effectively adapt to radical changes abroad.

2. The Building Blocks of a System of Innovation

To make things clear, let us first clarify some of the fundamental concepts that are often used in systems of innovation research. Like all systems, systems of innovation are constituted by various *components* and the *relations* between them. Together, they can be said to define the *structure* of the system. Apart from a structure, the system can also be described in terms of its style, an important issue that will be discussed in detail further below.

With respect to the structure of a system, the most important components in systems of innovation are *organizations* and *institutions* (Edquist 2005, 188). However, there is some confusion with respect to the notions of institutions and organizations. If one takes North's distinction between institutions as 'the rules of the game' and organizations as the 'players' or 'actors' (North 1990) – as this study does – it appears that some authors (notably Freeman 1987, 1; Lundvall 1992, 2) with their respective use of the term 'institution' actually include certain types of organizations under this label. Edquist and Johnson (1997) have argued convincingly that innovation research should follow North's distinction, not least because the influence of institutions and organizations on each other is crucial for our understanding of systems of innovation. If these two groups of components are blurred, it is obviously difficult to speak about their potential influence on each other.

On the other hand, despite the 'conceptual diarrhea' in this respect (Edquist 1999), there is a striking agreement in the literature that both organizations and institutions of very *different kinds* need to be taken into account in the analysis of systems of innovation. With respect to organizations, it has been increasingly emphasized that not only firms, but also a variety of *non-firm organizations* are important actors (Freeman 1987, 1; Edquist and Johnson 1997, 58; Carlsson *et al.* 2002, 234; Malerba 2002, 250). In systems of innovation research, firms are still recognized as belonging to the most important organizations in the system. However, in the absence of non-firm organizations, it is difficult to arrive at a clear understanding of the dynamics of innovation and the evolution of systems. To non-firm organizations belong a wide array of actors stretching from educational and research organizations such as universities, academies and research institutes to government agencies, industry associations, labor unions, lobby groups, standard committees, etc.

It should perhaps be pointed out that the strong emphasis on the need to include non-firm organizations should not be confused with seeing systems of innovation as including only non-firm organizations, i.e., excluding business firms. The system of innovation should thus not be confused with, for example, the 'public support system'. Similar to traditional approaches in economics, such a perspective would miss a key argument of the very idea of systems of innovation, namely the interrelations between often radically heterogeneous actors in both the private *and* the public sector. (While economists thus often make the mistake to overemphasize the role of firms in systems of innovation, political scientists tend to overemphasize the role of public policy and the state in the dynamics of the system.)

The components referred to above as 'institutions' – i.e., the 'rules of the game' – can, like organizations, be of very different kinds. Above all, they can be both 'formal' and 'informal'. *Formal institutions* should not be confused with organizations such as universities or government agencies, although this happens frequently in the literature as well as in everyday language. Instead, formal institutions are codified rules such as laws, official standards, regulations and recommendations. These are consciously created and upheld by organizations; for example, national patent laws are in most countries approved by national parliaments and upheld by patent offices and courts. Standards may be created by public agencies but also agreed upon by the members of industry organizations, etc. Organizations thus have a strong and direct impact on the dynamics of institutions in systems of innovation. On the other hand, the purpose of formal institutions is usually that they should influence the behavior of organizations in certain ways. Hence, the relations between organizations and institutions may matter considerably for the dynamics and evolution of the system.

Informal institutions include uncodified traditions, norms, routines, taboos, etc. A typical informal institution is, for example, the norm of honesty in and among organizations or, in contrast, the acceptance of corruption. In contrast to formal institutions, informal institutions can seldom be created suddenly or rapidly, and they therefore almost always show strong continuities. This is because they are necessarily – though to a varying extent – deeply rooted in human consciousness, business history, legal traditions, etc. In times of radical political and economic change, this may give rise to substantial tensions and contradictions between the formal and the informal sets of institutions, since old informal institutions may continue to exist long after the accomplishment of formal changes.

The *relations* in systems of innovation are crucial, since it is mainly the relations that shape the dynamics of the system (Carlsson *et al.* 2002, 234). The most important relations in a system of innovation include those between organizations and institutions, as well as inter-organizational links such as cooperative, transactional and competitive relations among firms and other organizations (Edquist 2005, 195ff). Nowadays it is common that firms both compete and cooperate with each other at the same time; one may then speak of 'coopetition'. The fact that both cooperative and competitive relationships between organizations have grown stronger and more important during the past decades is one of the strongest motivations for using a systemic approach to the analysis of innovation. This in turn emphasizes the need for understanding the relations between organizations and institutions, since institutions may strongly influence both cooperative and competitive relationships.

An important characteristic of systems of innovation is that inter-organizational links are seen to consist of both *market* and *non-market* relations (Malerba 2002, 251; Carlsson *et al.* 2002, 234). Inter-organizational relations can therefore not be traced fully by tracing economic transactions. In addition, inter-organizational links may be both *formal* and *informal* (Freeman 1992, 99). Due to the often large number of external links that organizations build with other organizations, it is often purposeful to study inter-organizational relations in terms of *networks* rather than of simple bilateral links. Networks contribute in important ways to the structure of systems of innovation, and are crucial for their dynamics (Carlsson *et al.* 2002). They are made up of a variety of inter-organizational relations such as strategic alliances, research consortia, joint ventures, licensing agreements, production sharing, direct investments, university-industry-government relations, organizational arrangements for financing innovation, subcontracting and other user-producer links (Tidd *et al.* 2001, ch. 8; Freeman 1992, 99). Since networks are usually considered to be more than the sum of these individual relations, it is important to see the relations as parts of the network. The relations within a network are influenced by each other and are therefore unlikely to be properly understood without the broader picture of the network.

3. Activities in Systems and Styles of Innovation

As mentioned above, components and relations, taken together, define the *structure* of systems of innovation. However, as we are here concerned with creative destruction and related processes of transformation and change – rather than with analyzing a system of innovation as it appears at one point in time – it is above all necessary to conceptualize the actual *processes* that take place in the system. To deal with this issue, I would here like to introduce the concept of 'activities' in systems and propose the notion of 'styles of innovation', whereby the latter is defined as the aggregate pattern of the activities and the relations between them as it appears in a specific system and at a specific point in time. The point of departure is here the overall *function* of systems of innovation, which is the creation, diffusion and utilization of innovations (Edquist 2005, 190). For a system of innovation to perform this overall task, a variety of activities take place in the system.[2] The activities describe what is 'happening' in the system and they can be interpreted as the *determinants* of the overall function.

There is no consensus in earlier research as to what the relevant activities in a system of innovation actually are or how important certain activities are in relation to each other, although several authors (notably Rickne 2000; Liu and White 2001; Bergek 2002; Jacobsson 2002; Edquist 2005) have tried to provide listings of what, in their view, constitute the most important activities. What these authors have in common, however, is their argument that activities of very *different* kinds have to be taken into account if we are to grasp what is happening in a system of innovation. In particular, the activities that take place in a system of innovation are much broader than the notion of 'innovative activities' in a traditional sense – in particular if the latter are defined in terms of mere 'R&D activities'.

To illustrate this argument, let us briefly discuss some typical activities that are often considered important for the success of a national system of innovation:

- *Formulation of visions.* This includes activities pursued by firms and other organizations to identify market and technological opportunities – as well as to recognize limitations in these opportunities, and actors' critical reflections on

2 – Some authors prefer to speak also of the activities in terms of 'functions', which are then understood as subtasks relating to the overall function of the system of innovation. To avoid confusion, I here follow Edquist's (2004) suggestion to speak of the overall function of the system and the activities going on to serve this overall function.

their own suitability to take part, in some way or the other, in the risky creation and exploitation of opportunities. The formulation of visions also includes the often very difficult recognition of shortcomings in old behaviors. The formulation of visions should not be interpreted in purely technological terms; visions, as understood here, also include the scope for creating new partnerships, alliances, collective identities, etc.

- *Articulation of demand for new, improved and cheaper products.* This includes, on the one hand, demand for already existing products that are in a fluid stage of development and for which market growth may be a crucial prerequisite for the process of further improvements. On the other hand, it also includes the demand for products that do not yet exist. The articulation of demand is an integral part of what in evolutionary economics is referred to as the selection process, since the differing demands for alternative products typically have a considerable impact on their chances for survival.

- *Creation of new knowledge.* This refers in particular to the creation of new scientific and technological knowledge underlying new products and processes. It includes R&D activities in a traditional sense, but also the combination of old pieces of knowledge in new ways, with the purpose of creating new products and processes. Knowledge typically accumulates in incremental and path-dependent ways, but radical shifts in knowledge-creating activities may take place by abandoning certain knowledge areas and deliberately choosing to focus on alternative knowledge paths.

- *Competence-building.* Building competencies is here associated with education and training. It is a matter of transmitting already existing knowledge, whereby the purpose is not primarily to create new products and processes, but rather to build up competencies that can later be used in the context of knowledge-creating activities. It may take place in a multitude of different settings, in particular schools and universities, and through internal training in firms and other organizations.

- *Formation of new firms and other organizations and market entry and exit.* Organizations may be formed in a variety of ways, including more traditional forms of entrepreneurship as well as through the creation of spin-offs from existing firms, universities, research institutes and other organizations, and through the establishment of subsidiaries of foreign firms, etc. With respect to market entry, new firms are typically accompanied by already existing firms that choose to diversify into new markets. Conversely, firms may exit from markets both through total bankruptcy, through mergers and acquisitions or by selling off non-core product areas.

- *Adaptation of organizations to accommodate for innovation.* Innovation is a process of change that is often very turbulent. Firms and other organizations therefore have to adapt themselves internally in a multitude of ways in order to respond to new opportunities and threats. It can be a matter of, for example, hiring new staff, forming new teams, reformulating strategies, changing organizational culture, responding to institutional change, etc.

- *Networking.* This includes creating, handling and exploiting collaborative links and networks, whereby the partners can be not only firms, but also universities, government agencies, regulatory boards, trade unions, etc. It also involves responding to the activities of competitors, handling external conflicts, breaking old relationships that have become dysfunctional or obsolete, etc. Networks are also channels of communication, which help organizations scan their environment for important signals in the system. This activity is closely related to the internal adaptations referred to above, since internal processes of change typically require mobilization of resources from outside or even acquisition of entire firms to support the internal innovation process.

- *Provision of finance.* In principle, all other activities discussed here are likely to be shaped by the extent to and ways in which funding is available. This goes far beyond R&D expenses in the traditional sense of this concept. Competence-building may be heavily dependent upon the financial situation of universities; new firm formation on the availability of venture capital; acquisition of external resources may involve licensing fees, investments into joint ventures and alliances; public policy might be meaningless in the absence of financial instruments to support and direct various activities in the system of innovation; etc.

- *Consultancy, advice and lobbying activities.* These activities play a crucial part in the information flows in most systems of innovation, although such flows may look very different in different cases. Consultancy, advice and lobbying activities may take place according to both formal and informal arrangements, they may involve foreign and domestic actors, public and private organizations, etc. Lobbying may be highly controversial, but may also be a key driving force in system evolution.

- *Creating, changing and abolishing institutions.* The rules of the game do not change automatically, but as a result of the activities of various actors, involving government agencies and business firms as well as various other organizations. Some organizations have among their main tasks explicitly the responsibility to engage in processes of institutional change, but these actors are seldom able to handle such changes on their own. Complex networks of actors may therefore emerge in the process of institutional change, whereby this activity may also relate closely to consultancy, advice and lobbying activities.

- *Formulation of public policy.* Public policy in the field of innovation can have substantial impact on the evolution of systems of innovation and should therefore be seen as an important activity taking place in systems. Public policy may be closely related to the creation, change and abolition of institutions and to the provision of public financial support. Since the activities in systems of innovation can be interpreted as the determinants of innovation (see above), public policy may seek to influence all other activities listed here – including the ways in which policy itself is being worked out.

The list of activities above does not necessarily indicate *how* or *by whom* they are carried out. The activities may have radically varying characteristics, be carried out in very different ways and by very different types of actors, depending on factors such as national, sectoral and historical settings, as well as on the evolutionary paths of systems. This relates also to what in systems of innovation research is usually referred to as a lack of 'optimality' (e.g., Edquist 1997b: 19f.); there is, as far as we know, no 'ideal' way to carry out the above activities. For example, R&D activities are typically carried out by vastly differing organizational arrangements in different – but perhaps equally advanced – countries. Similarly, the character of networking activities can be seen to differ vastly between different sectors and technological fields (typically as a result of different types of knowledge bases) (e.g. Breschi and Malerba, 1997).

From this perspective, it is hardly possible – nor desirable – to seek to identify any 'most suitable' character of the above activities and the ways in which they 'should' be carried out. A more important and compelling task is to analyze the ways in which the activities contribute to the overall function of the system, and how they develop matches or mismatches with each other. For example, the creation of radically new knowledge through aggressive R&D risks being useless for the system as a whole, unless new matching competencies are built up, relevant new firms are created to exploit the new knowledge, formal institutions are altered to remove legal obstacles, complementary assets are secured through networking activities, etc. In other words, the activities cannot be understood in isolation from each other, and the focus of analysis should therefore be on how the activities in systems of innovation contribute to the functioning of the system as a whole.

At the aggregate level, the activities taken together can be said to define the 'style of innovation' in the system. The style is thus defined as the aggregate pattern of activities and the relations between them, as it appears in a specific system and at a specific point in time. It follows that the style of a specific system reflects not merely the strength and nature of R&D and other knowledge creating activities, or the 'style of management' in a certain country or sector. Instead, styles of innovation, as interpreted here, also reflect factors such as the way in which institutional change is handled in the system, what types of visions underly systems evolution, how new firm formation is enabled, how competence-building is organized, what role lobbying plays for the functioning and evolution of the system, from what types of sources innovation is financed, etc.[3]

The notion of activities in systems and styles of innovation helps us see more clearly what the process of creative destruction is about in practice. In earlier research there has often been considerable confusion with respect to the unit of analysis in creative destruction processes, raising questions as to what it is that is actually being created and destroyed. Is it competencies that are being destroyed? Or firms? Or technologies? etc. With the approach proposed here, it becomes natural to analyze creative destruction as a multi-dimensional process that takes place across the entire range of activities in the system, thus radically altering the style of innovation in that system.

Hence, creative destruction may take place with respect to each and every activity listed above: it may be a matter not only of competencies and organizations being created and destroyed, but equally of new visions replacing old ones, old demand giving way for new demand, new dynamic innovation networks and relations taking the place of old ones, new methods of financing innovation coming in to replace obsolete sources of finance etc.

3 – Hence, the concept of style is also broader than the notion of 'technological paradigms' in previous research on innovation (e.g., Dosi, 1988) and, in the sociology of technology, 'technology traditions' (e.g., Berner, 1999).

4. Understanding System Boundaries

In the preceding sections it was argued that a wide range of organizations, institutions, relations, and activities should be taken into account when analyzing the nature and dynamics of systems of innovation. On the other hand, however, a system of innovation does certainly not include *everything*. A key characteristic of any system (not only systems of innovation) is that it has a *boundary*, implying that some things belong to the system while other things do not.

Boundaries of systems of innovation can in general be defined in terms of geography and/or in terms of product areas or technological fields.[4] In the case of national systems of innovation, the boundary of a system is defined in terms of *geography*. National borders are then seen to coincide with the system boundary. Organizations, institutions and activities in foreign countries are in this interpretation not seen as being part of the system, but belong, instead, to the *environment* of the system. Based on systems theories in political science and sociology, one may discern two somewhat different but related ways of determining whether national boundaries can be said to define system boundaries:

- First, following the political scientist Karl Deutsch, one might suggest that national borders define the boundary of a system if the intensity and number of domestic relationships (i.e., among domestic organizations and institutions) is much greater than the intensity and number of transnational relationships (i.e., between domestic and foreign organizations and institutions) (Deutsch 1963, 205). I will refer to this as a *Deutsch-type boundary*.

- Alternatively, building on the reasoning of the sociologist Niklas Luhmann, one may argue that national borders define the boundary of a system if interactions with the foreign environment have a different impact on that system as compared to the impact on other national systems, in terms of structure and style (Luhmann 1984, 17). I will refer to this as a *Luhmann-type boundary*.

An interesting issue is to what extent and in which ways these two types of boundaries are related to each other. For example, does the existence of a Deutsch-type boundary automatically imply that there also exists a Luhmann-type boundary, i.e., do strong domestic relations lead a country to develop a system with its own, nationally specific structure and style? Or conversely, does the existence of a nationally specific structure and style automatically imply that domestic relations are much more intense than relations across national borders? Clearly, empirical research on specific countries is needed to shed light on this issue. However, in a preliminary way, I would here like to suggest that a national system, strictly defined, has to fulfill *both* the above criteria.

The actual existence of national systems in that sense is indicated by the often radically differing organizational and institutional structures and styles of innovation in different national contexts, and of the continuing importance of strong domestic relations – even in an era of globalization. Even countries which show strong relationships to each other, such as Sweden and Denmark, have been found to differ greatly in their structures and styles (Edquist and Lundvall 1993, 5f.).

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4 – A somewhat different way of thinking about boundaries is to ask which organizations, institutions, relations and activities within a specific geographical or sectoral context are actually to be interpreted as belonging to the system of innovation, as opposed to activity fields within that context which are not related to processes of innovation. For example, not all business firms are relevant in the study of innovation, but only those that actually have a notable direct or indirect influence on innovative outcomes. See Edquist (1997b) for further discussion on this issue.

5. Creative Destruction: Can the System Respond?

How can systems of innovation be expected to behave when facing a radical transformation pressure, as in the case of creative destruction? In fact, systems of innovation analyses have often been criticized for being too static, i.e., for not taking into account how and why systems evolve and change over time (see, e.g., Balzat and Hanusch 2004, 205). This is ironic and paradoxical, as innovation researcher usually argue that their object of study is a changing reality in a variety of dimensions. Moreover, in cases where the interest has been explicitly in system evolution, it has mostly been a matter of the emergence of 'new' systems – either around a certain new technology (e.g., Carlsson 1995 and 1997; Rickne 2000; Jacobsson *et al.* 2004), or in developing countries that for the first time ever see the emergence of systems of innovation (e.g., Nelson, 1993, chs. 11-15; Muchie *et al.* 2003). Much less effort has been spent on how already existing systems of innovation undergo transformation in response to (often radically) changing external and/or internal circumstances.

In the following I will in a theoretical way propose a view of how systems of innovation can be seen to transform in response to radical external and/or internal pushes and pulls. Such pushes and pulls may include, for example, a dramatic political shift – such as the collapse of the Soviet Union or the re-engineering of West European welfare states in the 1990s – or the emergence of a radically new technology – such as the Internet or mobile telecommunications in the 1990s. From a systems theory viewpoint, both of these types of changes represent strong disturbances from the perspective of the system, with the power to radically transform it, in terms of both its structure and its style.

Structural Transformation

The *structure* of a system of innovation in terms of its components and relations is transformed through reconfigurations in the organizational and institutional landscape. This involves changes in and destruction of existing components and relations, but also the emergence of new components and new relations. Structural transformation of systems of innovation is thus reflected in the emergence of new types of innovating firms (and other organizations) and the disappearance and transformation of old ones. It also includes the transformation of inter-organizational networks, through the creation and destruction of various types of links between organizations. In the same way, the institutional landscape undergoes transformation through the creation, destruction and adaptation of institutions, and through the changing relations between different institutions. In addition, the links between organizations and institutions undergo changes.

Since components and relations may be of very different kinds (see above), structural transformation may take very different forms. It includes not only changes in the population of firms, but also the creation, adaptation and destruction of government agencies, research institutes, universities, industry organizations, lobby groups, etc. Similarly, the structure of relations may be transformed in a variety of ways, including changes in collaborative, transactional and competitive relations between firms as well as between firms and non-firm organizations, between formal and informal institutions, and between organizations and institutions.

These changes in the structure of the system are not independent of each other. The change in a component or a relation has often far-reaching consequences for other components and relations. This is, of course, one of the most fundamental aspects of any systems approach to innovation. Through the activities occurring in the system (see above), components respond to changes in other components and in their interrelations, in order to 'fit' in the system as it undergoes transformation and develops a new structure. Components are therefore not free to change in arbitrary directions, but are for their survival forced to take into account the state of the system as a whole.

When a radical change shakes a national system of innovation, structural tensions result within the system. For example, if a set of formal institutions are suddenly replaced by a new set of formal institutions, this results in an initial mismatch between these and the rest of the system. Components and relations, which have so far been adapted to the old situation, will sense a need to respond to the radical change. However, the extent to which they can actually do so is limited by a number of factors. For example:

- *Informal institutions*, in contrast to formal institutions, seldom change suddenly or rapidly, but rather evolve in incremental ways (North 1990, 6). This is because informal institutions are closely related to behaviors and habits that take time to learn and unlearn. For example, in a system where market forces for decades have not been allowed to play any important role in the system of innovation (such as in socialist systems of innovation), it may require much effort and time to develop a new habit of thinking about the role of the market. Unfortunately, human cognitive capacity is severely limited, and cannot be 'reprogrammed' overnight. This is not to say that change is not possible at all; however, it may require years, decades or even generations for tensions between formal and informal institutions to be resolved.

- *Formal institutions* may in principle be altered instantly, for example, through a change in legislation. In practice, however, institution-building is a difficult activity which requires advanced and relevant competencies, and formal institutional change is therefore dependent upon the availability of such competencies. For example, the creation of a legal act regulating the Internet-related use of databases, is likely to require far-reaching knowledge about the Internet and of database technologies. There is also a need for knowledge about how a new formal institution fits into the overall structure of formal institutions, in order to minimize the emergence of new contradictions among various legal acts and other formal rules, norms, standards, etc. If institution-building competencies are weak, it may take a long time before formal institutions can adapt to changes in other parts of the system. This is particularly important in times of rapid technological change, which often make existing institutional arrangements obsolete. If a national system of innovation then lacks the necessary institution-building competencies, the result may be difficult bottlenecks that prevent a more far-reaching innovative dynamism.[5]

- Similar to formal institutions, *organizations* are also consciously and directly created by people, involving both individuals and other, already existing organizations (e.g., North 1990, 5; Edquist and Johnson 1997, 47). Organizations are therefore dependent upon the availability of individuals and organizations that can create and develop them, as well as upon the availability of other resources in the system (such as finance and consultancy services). When such factors are lacking, it may be extremely difficult for organizations and inter-organizational networks to respond to important changes in other parts of the

5 – This argument relates to classical ideas on the interrelations between technological and institutional change, perhaps most brilliantly expressed in the Marxian dialectics (e.g. Marx and Engels, 1848; see also Rosenberg, 1982). It also relates to the interest expressed by North (1990), Rosenberg and Birdzell (1986), Murmann (2003) and others, in how differences in the institutional histories of countries can be seen as a major determinant of their economic performance.

system. For example, a new formal institution designed to stimulate the creation of small technology-based firms may not lead to anything, unless there exist people with relevant knowledge, complementary organizations that provide finance and advice, etc. In addition, some types of organizations – for example, universities – are so complex that it may take a very long time to establish and transform them.

- *Relations* in systems of innovation tend to evolve in incremental and path-dependent ways. The source of innovation networks is typically found in inter-organizational relations that have evolved over a long period of time (Tidd *et al.* 2001, 215). The high risks – for example, in terms of information leakage – associated with acting in inter-organizational relations with the purpose of generating innovation, means that such relations often need to build on trust and effective routines, which take time to build. Conversely, links that have been successful in one context may be difficult to break, even if a changed context makes the existing links obsolete. The activities of organizations for innovation may have been built up in such close relation to external partners that the resulting systemic interdependencies put serious constraints to change (*ibid.*, 216). The adaptation of networks to an institutionally new situation is therefore likely to require considerable time and effort.

Hence, the structure of a system of innovation cannot be expected to respond in any automatic, let alone predictable, way to radical pushes and pulls. Instead, the pace at and extent to which structural tensions can be smoothly resolved, depends on factors such as the complexity and strengths of existing components and relations, and the availability of knowledge, competencies and experiences that are relevant in handling structural transformation. An important implication of this perspective is that empirical research has to address the *history* of the system if one wants to understand the dynamics of its transformation, i.e., it is important to ask 'from where the system comes'.

Both political and technological changes in a national system of innovation typically result in a more fluid and turbulent stage and is likely to give rise to a more loosely defined system structure. However, as components and relations continuously adapt to the new situation in circular and cumulative ways (Myrdal 1957, 16ff.), the system is likely to gradually take a more stable shape. Components and relations develop interlockings by adapting to each other, and once a more stable new structure begins to crystallize it becomes more and more difficult to change the structure in more far-reaching ways. Therefore, the key to understanding the emergence of a new structure should be searched for in the early years following the radical political or technological disturbance.

However, if the inertia of the earlier system is strong, strong external pushes and pulls may – paradoxically – have little impact on the system. The existing structure may simply be so strong and stiff that further changes are made difficult in the whole system, which therefore remains very much as it was. For example, a formal institutional change demanding the split-up of large conglomerates in Eastern Europe after the collapse of socialism may be followed by a reintegration of actors into networks that in practice are almost identical to the old conglomerates (Dyker and Radosevic, 1999). In the extreme case, the power of the old structure may lead to an abandonment of the new formal institutions (e.g., a revival of more Soviet-type institutions). This may be seen in analogy to technological discontinuities that fail to give rise to far-reaching systems transformation.

The Emergence of New Styles of Innovation

Just as internal or external disturbances have the power to open up far-reaching opportunities for structural transformation of systems of innovation, they also open extensive opportunities for changes in styles of innovation. The disturbance is likely to stimulate wide-ranging changes in the ways activities are carried out, and thus lead to a more fluid style of innovation. In such a state, where both the activities and their interrelations are undergoing changes, they will be easier to influence, as activities that have earlier been interlocked in a more mature style are likely to lose some of their momentum.

Sooner or later, however, the activities start to adapt to each other in interlocking ways, through processes of positive feedback that may lead to both virtuous and vicious circles. This is because a change in one activity is likely to demand adaptations of other activities, in order for the activities to fit with each other. For example, a new articulation of demand may stimulate the creation of new knowledge, and if this is associated with the formulation of new visions, there may be scope for public policy-making activities that, for example, may support the process through financial means, investment in competence-building or other activities. In the ideal case, the activities influence each other in such a way that mismatches between them are resolved. This then results in an increased innovative dynamism (Myrdal 1957, 19). It may take a long time – years or decades – for activities to develop matches between each other in such a way that far-reaching creative innovation and system dynamism are enabled.

But the activities may also develop in relation to each other in such a way that the system is locked into more problematic styles of innovation. For example, lack of demand may lead to shut-down of knowledge-creating activities, so that the style moves in more imitative directions, for example, through non-innovative subcontracting agreements as the main way of staying alive.

The way in which a style responds to pushes and pulls is also dependent upon the already existing system. To understand this, one may connect to the argument in social systems theory that a system is capable of reacting to change only in accordance with its own logic, rationality and history (Luhmann 1986, 15ff.). In other words, depending on the structural configurations and the often long-established traditions of carrying out certain activities in a system, different systems are likely to deal with new problems in very different ways.

For example, although the collapse of socialism was a radical political change that occurred in a large number of countries at roughly the same time, systems of innovation in different post-socialist countries did not respond to the radical political change in the same ways. In other words, different systems develop different styles of innovation in dealing with the problems and opportunities associated with the new institutional situation. One country may have a particularly strong R&D base that is deemed relevant for the post-socialist context, and may therefore seek to build a style that is based on strong knowledge creation activities. Other countries may have a much weaker R&D base, but may have a tradition of flexibly adapting their institutional environment to new technologies, which may give them a somewhat different advantage. Yet other systems may see that the new technology is associated with opportunities that require inter-organizational collaboration of a kind in which it has earlier experience. While it is hardly possible to identify any optimal way of responding to new opportunities, it therefore seems natural that different systems interpret the new political situation and its opportunities in different ways with respect to potential innovation. This is in line with the argument above that it is not possible to define any 'ideal' or 'optimal' system of innovation (see, e.g., McKelvey 1997, 202; Edquist 2005, 185).

In the same way as for structural transformation, the immediate years following the disturbance may be expected to be of crucial formative importance for the transformation of styles. Steps taken in one way or the other with respect to the different activities during these years will undoubtedly be followed by adaptations of the activities to each other in such a way as to fit with the new formal institutions. As a consequence, major future adjustments in any activity will be much more difficult to carry out than in the very first few years. Hence, the opportunities related to the 'new freedom' will quickly be followed by the risk of becoming locked into new – advantageous or disadvantageous – styles of innovation.

6. Pushes and Pulls from Abroad

Systems of innovation are seldom *closed* systems. In other words, systems of innovation communicate and interact with their environment. Thus a system of innovation has an influence on its environment, and the environment has also an influence on the system (Hughes 1987, 53). In the context of small countries, the latter aspect is obviously much more important than the former aspect, i.e. the small system's environment has a much greater influence on the system than the system has on its environment.

Hence, the influence of the foreign environment can be expected to be crucial for a small national system of innovation. This is especially so when it comes to processes of creative destruction. The pressure to creatively destroy components and activities in a small system of innovation often comes from outside rather than from within, and the success of the system is highly dependent upon its ability to effectively adapt itself to the radical changes in its environment. In the following I will theoretically discuss the prospects for a small system of innovation to effectively adapt itself in the process of creative destruction that transcends the system's geographical boundary.

From a formal-theoretical point of view, a system cannot be influenced directly by another system, but only by the environment, in which (actors in) the system, however, may discern other systems. Building on the above analysis of how styles of innovation emerge, whereby it was emphasized that a system is capable of adapting to changes only in accordance with its own structure, rationality and history, it can be seen that a system is unlikely to be influenced by the environment in any random way; instead, the way in which the system responds depends very much on its own internal characteristics. Two systems with different structures and styles are therefore likely to react in different ways to the same outside pushes and pulls.

More interesting, however, is the question as to what the forces actually are that determine the impact of the environment upon a system. In social systems theory, Luhmann argued that the environment can only have an impact upon a system if there is 'resonance' at the system boundary (Luhmann 1986, 15ff.). The metaphor comes, of course, from physics, where the oscillations with a certain frequency in a medium (a system's environment) can make another medium (the system) with the corresponding eigenfrequency oscillate. Socially, resonance can also be said to occur when people react to messages from each other (through language or other media). Naturally, it is easier to communicate if there exists a common or related language.

The most plausible interpretation of this argument in our case is that a system of innovation reacts to signals especially from those systems in the environment with which it has strong economic, political, cultural or other similarities and ties. This is because such external systems are usually the ones with which it is easiest to communicate in a meaningful way. For example, a system of innovation in a European country is likely to react more strongly to signals from other European systems, but more weakly to signals emanating from Japanese or Chinese systems, with which it has less strong economic, political and cultural links. This is in line with research on, for example, management of innovation, where it has been found that European firms find it considerably more difficult to learn from Japanese firms than from European and North American firms (Tidd *et al.* 2001, 94).

This may also relate to the interesting relation between capitalist and socialist systems of innovation during the Cold War period. For example, in Soviet-era systems of innovation the activity of new knowledge creation sought to a great extent to build upon the further exploitation of Western technological advances; the general strategy was to first imitate Western technologies and then develop them further domestically. In reality, however, Soviet-type systems showed great difficulties in 'learning from capitalists'. Imported technologies hardly ever acquired a dynamics of their own, but worked as static enclaves in the centrally planned economy (Sandberg 1989). For example, modernizations were made only with new support-package deals, and diffusion to other sectors than the military or space industries were minimal (*ibid.*). One possible interpretation of this would be that the great differences in the political and economic environments in East and West during the Cold War prevented a more efficient communication between socialist and capitalist systems of innovation.

Freeman, though not referring to social systems theory, has connected this line of reasoning to theories of catch-up in innovation, arguing that catch-up countries that are located in geographical proximity to leading systems of innovation or that have strong cultural, economic, political and other links to them, should have a clear advantage as compared to catch-up countries located further away from and having less affinities with advanced systems (Freeman 1994 and 2002). This idea is supported by historical evidence showing that the most successful catch-up countries in different historical periods have nearly always been located in cultural or geographical proximity to the most advanced national systems of innovation.

Thus the British leadership in the 18th and early 19th centuries was followed by a rapid catch-up process taking place in the culturally close United States and the geographically close Belgium, Germany and other continental European countries. Scandinavia and Eastern Europe, in turn, both of which lie culturally as well as geographically close to Germany, were then the next to follow. In the 20th century, a similar pattern can be observed in East Asia, where the 'Tiger' economies have been located in proximity to the leading country of that region, Japan. Empirical evidence shows that Japan and later South Korea have played key roles in the catch-up process of other countries in the region (Freeman 1994, 214f.). In particular, China profited substantially in the 1980s and 1990s from linguistic, cultural and close family ties to Hongkong and Taiwan (Hobday 1995, 23).

From a somewhat different perspective, Bresnahan and his colleagues came to the same conclusion. They studied the emergence of ICT-related clusters in a number of countries, whereby they stress the importance of connections to advanced ICT markets – in particular the US market. The highly successful clusters in Ireland, India, Israel and Taiwan are seen to 'come from regions that, for one reason or another, have easier potential interactions with the US market (language, cultural connections, diaspora, etc.)' (Bresnahan *et al.* 2001, 843). This also relates to the issue of innovation networks, which play such important roles in most modern systems of innovation. For such networks to work efficiently, personal relationships of trust and confidence (and sometimes of fear and obligation) play important roles, and therefore 'cultural factors such as language, educational background, national loyalties, shared ideologies and experiences, and even common leisure interests continue to play an important role in networking' (Freeman 1992, 100).

As a contrast, one may also note the *absence* of strong catch-up in South America and Africa, which are geographically and culturally farther away from the world-leading systems of innovation (Freeman, 2002).

From the above discussion it may be concluded that strong links to an environment of leading systems of innovation seems to be a clear advantage when seeking to manage creative destruction in small systems of innovation. To be sure, however, there are many cases of systems of innovation that have not been able to exploit this vast potential. For example, not all East Asian countries have managed to develop successful national systems of innovation. Similarly, a country such as Mexico has found it extremely difficult to profit in terms of innovative performance from its proximity to the United States. In those catch-up countries that *have* been successful in the 20th century, however, it seems to be a common characteristic that the *government* has played an important and active role. This has included both important political choices with respect to issues such as technological and sectoral specialization, but also in a crucial way heavy investments in education. The success in exploiting geographical and culture proximity to leading systems of innovation systems thus appears to depend on these activities (see, e.g., Hobday 1995; Freeman 1994 and 2002).

7. Conclusions

This chapter started out with a conceptualization of national systems of innovation, taking the systems concept seriously by analyzing the nature of national systems of innovation in terms of their components and relations, their activities and styles and their geographical boundaries. It was emphasized that in order to understand systems of innovation in a dynamic sense, we need to take into account all these dimensions, i.e. not only the components (organizations and institutions) in the system, but more importantly how these contribute in their different ways to the activities taking place in the system.

The chapter showed that the notion of activities in systems and styles of innovation helps us see more clearly what the process of creative destruction is about in practice, and how policymakers can contribute to manage this process. With the proposed approach it becomes natural to analyze creative destruction as a multi-dimensional process that takes place across a wide range of activities in the system. Hence, creative destruction may take place with respect to each and every activity: it may be a matter not only of competencies and organizations being created and destroyed, but equally of new visions replacing old ones, old demand giving way for new demand, new dynamic innovation networks and relations taking the place of old ones, new methods of financing innovation coming in to replace obsolete sources of finance etc.

In the discussion of system boundaries, we distinguished between two different interpretations of these: Deutsch-type boundaries and Luhmann-type boundaries. Strictly speaking, it is only Luhmann-type boundaries that motivate the use of the concept of 'system', because in the absence of Luhmann-type boundaries, a 'system' is reduced to a network or a structure. At the same time, however, in order to explain the dynamics of systems, as defined by Luhmann-type boundaries, the analysis has to address interactions within the system and between the system and its environment – an issue that is closely related to Deutsch-type boundaries. Therefore, any approach that does not take into account both Luhmann-type boundaries *and* Deutsch-type boundaries is not a 'true' systems approach.

In our rapidly globalizing era, the importance of understanding national systems of innovation in relation to their foreign environments is clearly increasing. Globalization in the sense of increasing interactions across national and hence system boundaries means that it is becoming increasingly difficult for national and regional policymakers to try and influence domestic innovation processes. These increasing difficulties do not mean, however, that meaningful policymaking is not possible. Rather, they create a need for a deeper understanding and more thorough analyses of how national systems of innovation function and how they can be influenced. The ideas developed in this chapter can hopefully contribute to this.

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IV. NANOTECHNOLOGY AS A GENERAL PURPOSE TECHNOLOGY? – INSIGHTS FROM A FINNISH VIEWPOINT

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Abstract

Hardly any other field has received so much public R&D investments globally in such a short time as nanotechnology. Nanotechnology can be considered as an umbrella term for R&D at the nanometer scale (1-100 nm) where unique phenomena enable novel applications. The interest given to nanotechnology is largely due to its perceived, and partly also over-hyped, generic nature and potentials to renew industries in a revolutionary way. Nonetheless, the field is still in a fluid and uncertain phase without clear indications of how and where commercial breakthroughs will emerge on a larger scale. This paper discusses to what degree nanotechnology fits the criteria of a general purpose technology (GPT) as many claim, reviews the extant empirical research towards this end, and provides a brief overview and new insights into the development of nanotechnology in Finland. The case of Finland – as a small country – is interesting due to recent and relatively significant nanotechnology policy initiatives and the competitive position that it holds in many traditional industries. Although new firms also are emerging, Finnish nanotechnology primarily appears to be driven by scientific developments and the role of large firms is still small. Patenting is picking up but from a low level, and process engineering and chemicals are emerging as the main application fields.

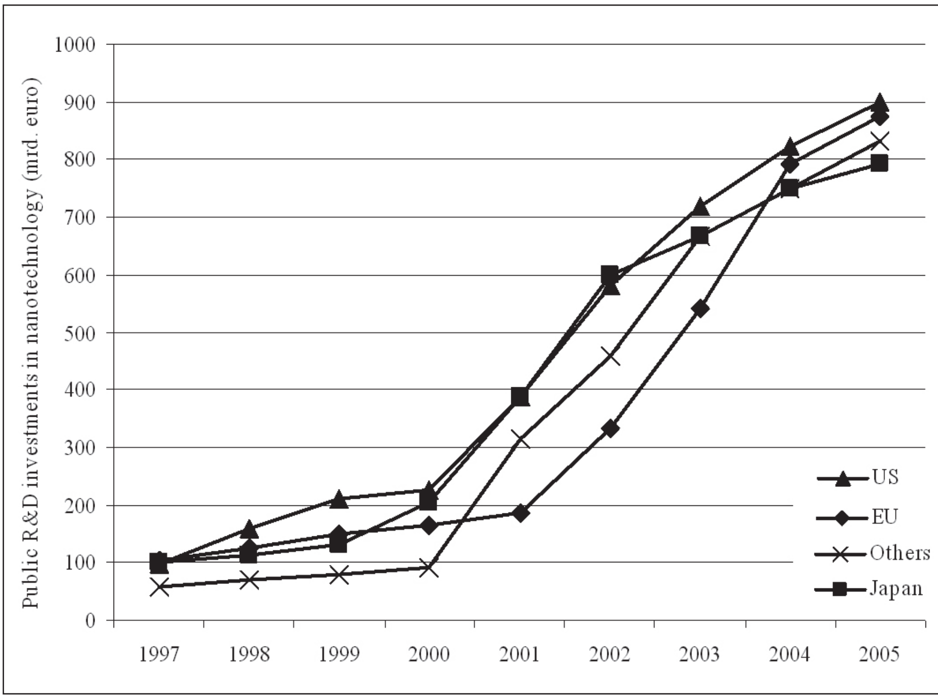
1. Introduction

1.1. Background

So called general-purpose technologies play an increasingly important role for the competitiveness of industrialised countries. As the name suggests general purpose technologies are characterised by their potential widespread use to renew traditional industries and create new ones. They require a range of complementary technological and organisational innovations, but once such general purpose technologies diffuse throughout economies they can function as the 'engines of growth' for extended periods of time. Steam power and electricity are commonly used examples of such technologies. There is also mounting empirical evidence that information and communications technology (ICT) has similar characteristics, and some commentators also point to the potentials of modern biotechnology in this context (Freeman and Perez 1988; Helpman 1998; Jovanovic and Rousseau 2005; Lipsey *et al.* 2005; Drechsler *et al.* in this volume).

As the examples of ICT and modern biotechnology suggests general purpose technologies have long incubation times before they reach the momentum required for becoming new engines of growth. Nonetheless, governments in many industrialised countries eagerly search for, and seek to support the development and diffusion of, these types of technologies to prepare themselves for tightening global competition and the next phases of industrialization. The most recent example is nanotechnology as an umbrella term for R&D at the nanoscale. In fact, hardly any other technology field has attracted so much public funding globally in such a short time as has been the case with nanotechnology and private funding is also picking up rapidly (Lux Research 2006). The attractiveness of nanotechnology primarily relates to its highly generic nature and – partly also over-hyped – potentials to renew existing manufacturing processes, products, services and industries in a revolutionary way. Hence, countries and regions around the world now seek to establish leading positions in this field.

Figure 1. Estimated public nanotechnology R&D investments



Source: PCAST 2005.

Figure 1 illustrates the rapid growth of public R&D funding for nanotechnology, as defined by the US National Nanotechnology Initiative, across the European Union (EU), Japan, US and other industrialized countries lumped together. By these estimates funding increased worldwide over eightfold during the period from 1997 to 2005. The EU Commission has drawn up a coordinated strategy towards nanotechnology. When the EU figures are broken down by countries it becomes clear that the smaller highly industrialised countries also are investing large sums into this new field. Further, the Nordic Innovation Centre is also activating itself with the aim of enhancing the competitiveness of firms throughout the Nordic countries through the application of nanotechnology (EU 2004; Nordic Innovation Centre 2006).

Nanotechnology is an interdisciplinary and science-based field that poses big challenges especially for small countries with limited resources. In Finland nanotechnology might be an especially interesting field due to its potential to leverage R&D and thereby add value to existing strongholds especially in traditional and maturing industries where global price competition is strongest. On the other hand, nanotechnology also demands absorptive capability, new expensive research facilities, instrumentation and the development of new commercialization avenues at the interfaces between industrial application and top-level scientific research. It is not self-evident that previous Finnish successes and capabilities in the development and production of ICT will be transferable to the field of nanotechnology (cf. with Palmberg and Luukkonen 2006). As a new field nanotechnology differs in many important ways both from ICT and modern biotechnology. It still in a very fluid and nascent phase and it is unclear where the most viable applications areas and commercialisation avenues for this technology are to be found. Apart from the hype and the technical literature there is very little substantial analysis on the economic significance of nanotechnology and on its potential to renew existing industries. Such analysis is especially important in a small country context where the risks of misguided R&D investments are the highest.

1.2. Aim and structure

This paper is intended to anchor the development of nanotechnology in the broader theoretical and conceptual framework of the economics of technological change. It also provides a review of the meagre but expanding empirical literature in this field, and presents some first analysis of the development of nanotechnology in Finland as an example of how a small country copes with technological change of a potentially higher order of magnitude. More concretely, the paper addresses the following two questions:

1. What is nanotechnology and how can the economic significance and potentials of this technology field be conceptualized in the theoretical literature on the economics of technological change? To what degree might we really expect nanotechnology to develop into a so-called general purpose technology as many claim?

2. Where does Finland stand in nanotechnology in international comparisons, which types of public sectors activities are emerging to support nanotechnology, and how is the related activity reflected in the science and technological developments as viewed by patent and publication data?

As has been suggested already, nanotechnology – as is typical for the emergence of new fields – is subject to a great deal of hype and science-fiction-type of speculation. The emergence of nanotechnology is also giving rise to a burgeoning and important technology assessment, forecasting and ethical discussions on how this technology should be regulated and use (see e.g. Langlais *et al.* 2004). It should be made clear at the outset that this paper will limit itself to an analysis of nanotechnology in the tradition of the economics of technological change.

The paper is structured as follows. Section 2 starts off with a discussion of the definition of nanotechnology. Section 3 turns to extant theoretical and empirical conceptualizations within the economics of technological change, focusing in particular on the concept 'general purpose technology' that might be useful for understanding nanotechnology. In section 4 the focus shifts to the case of Finland. It asses the position of Finland in nanotechnology from an international viewpoint, identify public policy initiatives, and related research and firm communities. Section 5 synthesizes the paper.

2. Defining Nanotechnology

As is often the case with generic technologies, definitions and delimitations of what comprises of nanotechnology are much disputed amongst scientists and engineers. Some claim that it represents a relatively coherent set of technologies that together mount to a new knowledge base that fundamentally challenges, and even disrupts, extant scientific and engineering principles. Others suggest that nanotechnology is a hype-word rather than a new technology in the sense that it merely redefines existing research agendas, and thus mostly enhances knowledge bases that scientists and engineers already draw upon (Andersen 2005). This discussion is ongoing and we will not dwell any further into it. Instead it makes sense to highlight a pragmatic definition of nanotechnology that is much referred to and useful also in our context.

On a very general level nanotechnology refers to new approaches to R&D that aims to control the fundamental structure and behaviour of matter at the level of atoms and molecules. This emphasis on smallness is reflected in the term 'nano' which refers to a microscopic measurement scale where 1 nanometre (nm) measures a millionth of a millimetre. Correspondingly, 100 nm measures a thousandth of a millimetre. For comparison, the thickness of human hair roughly corresponds to 50 000 nanometres. Precisely this smallness is also the clue to the scientific, technological and economic significance of nanotechnology. When the size of material approach the nanoscale they start to obey quite different laws of physics, based on quantum mechanics, and thus gain completely new – and as of yet less understood – properties in terms of chemical reactivity, optical, electronic and magnetic behaviour. This, in turn, means that materials potentially can find a range of new applications and uses throughout a very large number of industries (Hassan and Sheehan 2003; Hall 2005).

The surge in public R&D investment in nanotechnology has implied that pragmatic definitions of nanotechnology have been developed to set agendas. They have usually also centered on the measurement scale as a means of delimiting the type of R&D that falls into the nanotechnology category, while likewise stressing the importance that this R&D is directed towards new functionalities and applications of materials. In the history of public R&D funding for nanotechnology the National Nanotechnology Initiative (NNI) in 2001 in the US can be considered an important milestone due to its volume in terms of funding as well as the size and centrality of the scientific and engineering capabilities of the US R&D system (Ratner and Ratner 2003). The definition of nanotechnology that this initiative uses has become the most often referred to in policy circles and it will also be our point of departure:

> *"Nanotechnology is the understanding and control of matter at dimensions of roughly 1 to 100 nanometers, where unique phenomena enable novel applications. Encompassing nanoscale science, engineering and technology, nanotechnology involves imaging, measuring, modeling, and manipulating matter at this length scale."*
>
> (http://www.nano.gov)

This definition requires some additional clarification. The "understanding and control of matter" at the nanoscale refers to the rearranging of molecules so that essentially every atom can be put in its most efficient place so as to achieve a particular functionality. Nanotechnology is thus primarily a new production method that enables new product innovations. Further, nanotechnology is considered to encompass both the scientific knowledge base upon which it draws, as well as the engineering and technological activities that contribute to applications and commercialisation of this technology. This definition thereby highlights the very close linkages between scientific and technological developments that characterises this field (see e.g. Meyer 2000).

The science-base of nanotechnology is very interdisciplinary as it combines various subfields of physics and chemistry in its extension of the material sciences. Nanotechnology is also often associated with modern biotechnology, especially in some of the more futuristic scenarios (Hall 2005). On the engineering side one might identify two basic approaches, namely the 'top-down approach' and the 'bottom-up' approach. The former approaches existing materials at the nanoscale through traditional lithography, cutting, etc.hing or grinding techniques. Examples include various electronic devices, computer chips, MEMS or optical mirrors of very high quality. The latter approach actually creates new materials at the nanoscale through chemical synthesis or self-assembly of particle molecules and their macrostructures, such as crystals, films or tubes. Of these, the top-down approach has hence-far been the more common while the bottom-up approach still faces many bottlenecks (Andersen 2005; Hall 2005).

3. General Purpose Technologies

As already suggested economists have coined the concept "general purpose technologies" (henceforth referred to with the acronym GPT) to incorporate broad-based technologies, such as steam power, electricity, and ICT, into analysis of economic growth (Koski 2005; Jovanovic and Rousseau 2005; Lipsey *et al.* 2005). The usefulness of this concept comes with theoretical models that have been developed to better understand under which conditions and how GPTs might turn into the engines of growth for extended periods of time. Economists have for a long time recognized that technical change is the single most important force behind growth (see Verspagen 2005 for a recent review). Still formal theories have not sufficiently accounted for differentiated effects of different types of technological change. The concept GPT, and the related models, have been introduced to cater to this deficiency, the prime references being Bresnahan and Trajtenberg (1995), Helpman (1998), and Lipsey *et al.* (2005).

A GPT consists of a basic 'breakthrough' technology that is dependent on a range of complementary incremental technological and organisational innovations for its diffusion and ultimate effects. Hence, the ultimate effects of a GPT on growth will not only depend on its intrinsic technological characteristics. It will also depend on the degree to which usage patterns, firms, infrastructures, public policy, regulations and other institutional arrangements are conductive for technology diffusion. As a result, the growth effects typically manifest themselves in alternating periods of slowdown and acceleration in productivity as the examples of both electricity and ICT suggests (Jovanovic and Rousseau 2005).

The ideas of breakthrough technologies, the significance of complementary incremental innovations, facilitating economic and institutional contexts, and alternating phases of technology-driven economic growth are certainly not new. Similar insights are frequent in the Schumpeterian and evolutionary tradition of economics going back to Joseph Schumpeter (1911, 1942) and Nelson and Winter (1982) (see Fagerberg 2003 for a recent review). From the viewpoint of this paper the merits of the literature on GPT stems from the way in which it can be related to economic growth. Further, the literature offers an interesting and relevant discussion of necessary – albeit not sufficient – characteristics for a technology field to evolve into a GPT.

An elaborate discussion of the characteristics of GPTs is found in Lipsey *et al.* (1998, 2005). At the outset they acknowledge that technologies typically come in bundles due to various interrelations between core and complementary technologies, and often comprise of whole technological systems (cf. with the discussion in Freeman and Perez 1988). They also note that a GPT might, in its early development phase, be exogenous to the economic system while being endogenous to the science system. A GPT might therefore not initially be guided by profit-seeking decisions as often is the case in a university environment, although it needs to become so in order to contribute to growth. Further, they acknowledge that GPTs usually build incrementally on existing technological systems even though their ultimate effects might be radical (cf. also to the discussion in Carlsson *et al.* 2002). Beyond these general characteristics Lipsey *et al.* (1998) identify four somewhat more precise necessary criteria for a GPT.

First, a GPT has to have significant scope for improvement along economically relevant dimensions of merit so that its cost of operation will fall over time. Related to this, the second criterion is that a GPT has a widening variety of uses as it develops and the costs decline. In other words, it finds application in an increasing range of products and processes throughout different sectors of the economy. Third, it also has to find a range of different uses in the sense that a large share of the production activity in the economy uses the technology. Fourth and finally, it has to generate, and will also for its diffusion depend on, a range of other new complementary technologies and innovations.

4. Could Nanotechnology Become a GPT?

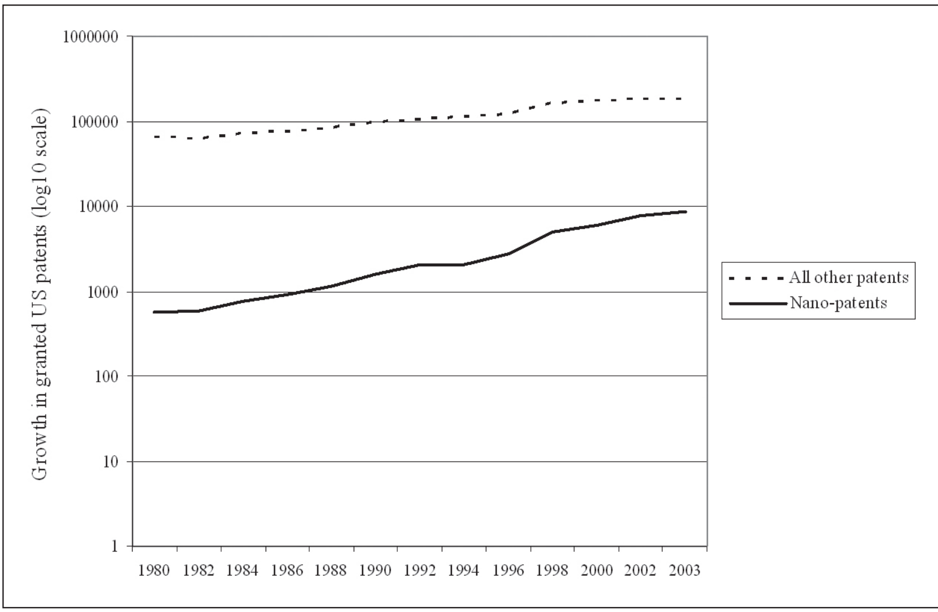
Our discussion hence far in this paper suggests that nanotechnology still is in a very fluid and uncertain phase of development, also when compared with modern biotechnology. Nonetheless, given the attractiveness of the technology field, especially in the eyes of public funders in most industrialised countries, it makes sense to step back and proactively pose the question whether nanotechnology might be a candidate for a GPT of the future. A pondering of this question can also contribute to a better appreciation of the specificities of nanotechnology, especially in the context of innovation policy. To what degree, then, could the four necessary criteria of a GPT also describe nanotechnology as it is emerging?

When considering each of the four criteria in turn, some perspective on the *first criterion* of the significant scope for improvement can be gained by looking at nanotechnology patenting as an indicator of perceived technological opportunities judged as commercially viable. Again an interesting comparative field is modern biotechnology where developments took off at an accelerating pace some 13 years after breakthroughs in genetic engineering in 1973 after which patenting of genetic sequences became possible and commercially lucrative. If this incubating period for technological breakthroughs is translated to nanotechnology developments the acceleration of nanotechnology patenting should have occurred some five years ago at the turn of the century, or some 13 years after the invention of the Scanning Tunneling Microscope (STM) and the Atomic Force Microscope (AFM) as the basic enabling inventions in this context (Darby and Zucker 2003).

Recent analysis of global nanotechnology patenting indeed shows accelerating growth with a significant lag following the basic enabling inventions. Using relevant keyword matches of the entire text fields of patents, Huang *et al.* (2004) trace worldwide developments in granted nanotechnology patents in the US as the most important market for high technology. They identify a strong upward trend after 1997, accelerating further after 2000 with a growth rate of 50%. This grossly exceeds the growth rate of 4% for patenting in all other fields. Interestingly patenting starts already in 1976 prior to the invention of STM and AFM microscopy, thus underlining that the concept nanotechnology also largely redefines existing research agendas.

Further, the distribution of patents is highly skewed across countries, pointing to the dominance of the US as a major developer of nanotechnology. Out of the 70 039 identified patents, the US assignees accounted for 61%, followed by Japan with 9%, Germany with 8%, Canada and France with 3% (cf. also to Marinova and McAleer 2002). Nonetheless, Korea, Holland, Ireland and China are the countries which have experienced the fastest growth in the number of nanotechnology patents in recent years.

Figure 4. The growth rate of nanotechnology and all other patens granted at the USPTO



Source: Huang et al. 2004.

These developments and observations get further confirmation in recent analyses of patenting in Europe. Heinze (2004) also finds accelerating growth in patenting after 1997, while the dominance of US assignees again is very clear with 43% of all patents. Similar to developments at the US patent office, Germany scores second with 16% of all European patents, followed by Japan with 9%, France with 6% and the UK with 4%. When country developments are normalized for the different size of economies Sweden, Switzerland and Israel stand out (see also Noyons *et al.*, 2003). In so far as patenting is a good indicator for the scope for improvement of a technology, it thus seems that nanotechnology is in the process of achieving this first criterion for a GPT although developments clearly hence far are concentrated to the US as the most significant countries also in terms of the size of its R&D system.

The *second* criterion of widening uses throughout various industries, as the technology develops, also provides a strong case for nanotechnology to evolve into a GPT. Nanotechnology foremost represents a new process technology relating to the scale of the processing of materials. As such it can be used throughout most manufacturing industries as the discussion in the previous section of this paper suggests. Nanotechnology is also increasingly incorporating modern biotechnology as it extends to nanoscale engineering of organic materials (Grodal and Thoma 2006). Nonetheless, the diffusion of nanotechnology will depend on the compatibility of the broader economic and institutional environment of industries where regional and national, as well as sectoral, specificities will matter greatly.

Some additional insights on the widening uses of nanotechnology can be gained from patent analysis in so far as the designation of nanotechnology patents to specific technology fields by patent offices point to industries where they might find application. This aspect is also covered in Huang *et al.* (2004) for patenting in the US, revealing a clear broadening of the application fields. The fastest growth occurs in various subfields of chemistry, biotechnology and drug development, and electronics components such as semi-conductors, transistors and solid-state diodes. In the European studies Meyer (2000a), Noyons *et al.* (2003), and Heinze (2004) detect a similar tendency both in terms of the broadening of application fields and their content.

An interesting point in this context is made by Ratner and Ratner (2003). They argue that nanotechnology, in fact, might face few barriers to consumer adoption, at least if hurdles related to regulatory issues and standardization is overlooked. Nanotechnology will be embedded in many existing products, such as computers and pharmaceuticals. As a consequence demand growth will not be curtailed by new product adoption processes, even though e.g. product designers and doctors will have new learning curves to engage in on the supply side. This contrasts with the Internet – as a core ICT technology – where consumers had to learn new aspects of computers to engage e.g. in e-commerce. On the other hand, Ratner and Ratner (2003) also highlight the problem of potentially very long product development cycles due to the nascent and uncertain phase of nanotechnology development.

The popular literature is filled with visions about the multipurpose nature of nanotechnology. The fulfilment of the *third criterion* of a GPT regarding the broad range of its usability will largely depend on when and in which applications and industries 'bottom-up' approaches to nanoscale engineering will emerge as a commercially viable production process. A further barrier for an increasing usability of nanotechnology relates to ethical and safety concerns. Regulations and standards governing the field are relatively non-existent but will surely develop as concern increasingly is raised about e.g. the health hazards of nanoparticles, interoperability of nanoscale devices and system (Rashba *et al.* 2004). One example of new nanotechnology-related legislation is the REACH directive within the EU that relates to the registration and authorization of chemicals.

For further insights a parallel can here be drawn to the multipurpose nature of ICT and modern biotechnology. Freeman (2003) asks why modern biotechnology apparently will not emerge as the GPT of the 21st century while ICT is in the process of doing so. He attributes the relative failure of modern biotechnology to problems of social and political acceptance, lack of appropriate skills, outright opposition in chemicals firms, and above all to the failures to achieve major costs breakthroughs. In contrast, ICT has been among the most widely politically supported technologies as the popularity of such terms as the "information society" and the "knowledge economy" demonstrates. The cost experience of ICT has also been completely different as a series of major technological breakthroughs (semi-conductors, integrated circuits, optical fibres etc.) generated a virtuous circle of cost reduction and expanding sales. Above all, ICT is truly multipurpose as it offers the possibilities of process control in almost every manufacturing and service industry.

The *fourth and final criterion* concerning the development of new complementary technologies and innovations is difficult to asses in the context nanotechnology since it is still in such a fluid and nascent phase of development. Some insights might again be gained by contrasting the ‘top-down’ approach to nanoscale engineering with the ‘bottom-up’ approach. In particular, it seems that ‘top-down’ approaches already now are partly compatible with lithography, cutting, etching or grinding manufacturing techniques already in use throughout various industries. They thus stand a better chance of generating new complementary technologies and innovations. ‘Bottom-up’ approaches mark a more radical departure from existing techniques and will thus be less likely to generate complementarities in the near future, especially amongst incumbent firms (Ratner and Ratner 2003).

New start-ups and university spin-offs might of course also contribute to the generation of complementary technologies and innovations (e.g. components or instrumentation, new organisations and business models) to support the diffusion of nanotechnology. This has perhaps most visible been the case in the ICT industry where various new Internet-based business models are re-emerging after the burst of the dot.com bubble. In the case of nanotechnology it is still difficult to spot such new organisational innovations, or business models, and it is hard to imagine what they might look like. Again new regulations and standardization might also be a critical to achieve complementarities between nanotechnology and others, as well as between firms and industries that use nanotechnology.

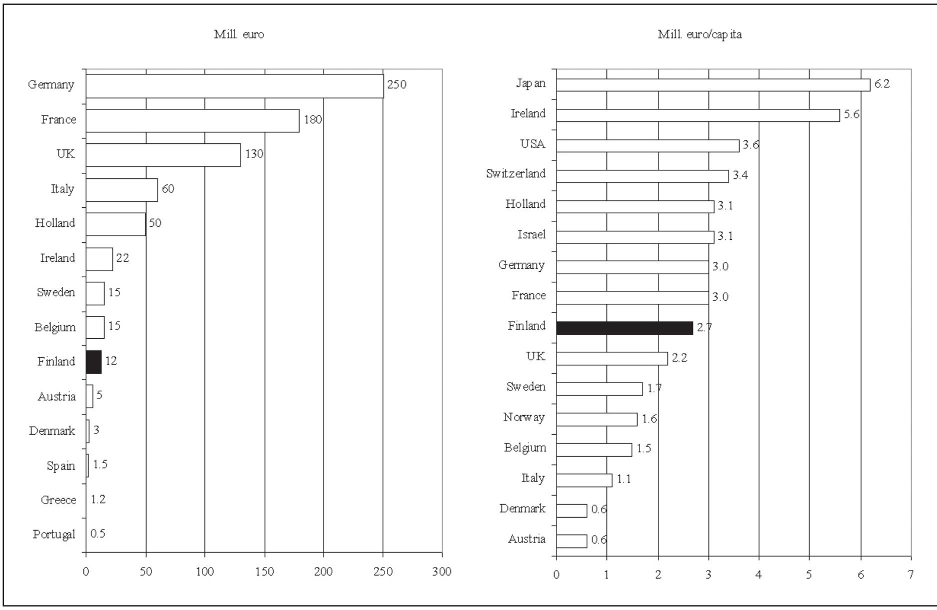
4. Finnish Nanotechnology Developments

4.1. Comparative R&D volumes and policy initiatives

By a comparison of the absolute levels of public nanotechnology investments we can detect a concentration to the largest countries within the EU, namely to Germany, and France followed by the UK. Of the smaller countries Italy and Holland are on top while Ireland, Sweden, Belgium and Finland invest approximately similar amounts. However, in relative terms, on a per-capita basis, the picture changes quite significantly. From this, more reasonable, viewpoint especially the position of Japan, and the smaller countries Ireland, Switzerland, Holland and Israel stand-out. Further, the position of Finland also strengthens and is elevated above the other Nordic countries Sweden, Denmark and Norway. Accordingly, Finland is a very small player in absolute terms but does invest quite heavily on a per-capita basis. Partly this might be a logical outcome of the general dedication of the Finnish government to R&D, as nanotechnology-related R&D is undertaken in a number of different industries.

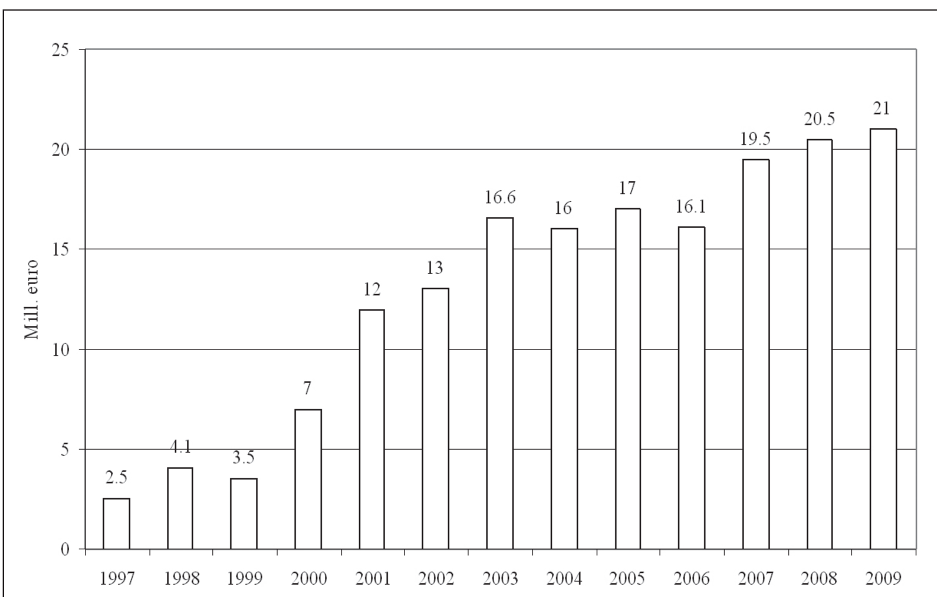
Previously public R&D investments in nanotechnology have been embedded in science and technology (S&T) programs with linkages to what has subsequently become labelled as nanotechnology. However, since the year 2005 these investments have mainly been directed towards dedicated nanotechnology programs commissioned by the Finnish Funding Agency for Technology and Innovation (Tekes) and the Finnish Academy of Science through the launch of the so-called FinNano-programs. These two public R&D funders commissioned an earlier nanotechnology program 1997-1999, albeit volume-wise much smaller. This earlier program focused on nanobiology, self-assembly, functional nanoparticles, nanoelectronics and biomaterials. The FinNano-programs will considerable increase public R&D investments into nanotechnology as Figure 6 below illustrates.

Figure 5. Estimated public nanotechnology R&D investments across countries in 2003



Source: EU 2004.

Figure 6. Estimated public nanotechnology R&D investment in Finland 1997-2009



Source: Ministry of Education 2005.

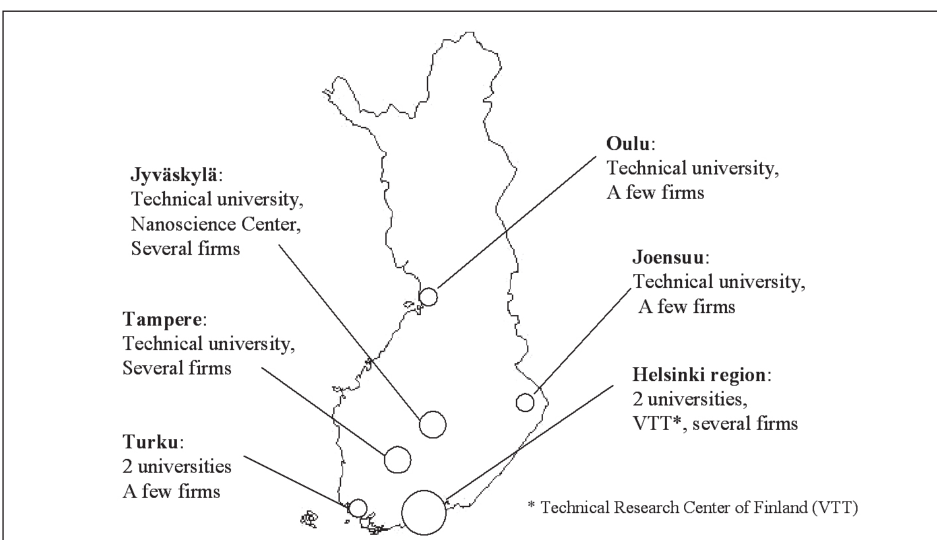
The program commissioned by Tekes aims to invest 45 million euros in nanotechnology during 2005-2009. Of this, 25 million is intended to cover research at universities or research organizations while 20 million is intended for firm R&D. The focus areas of the program are innovative nanostructure materials, nanosensors and –actuators, and new nanoelectronics solutions. Currently the program covers 20 individual firm projects as well as 15 collaborative projects involving also universities and the Technical Research Center of Finland (VTT). The whole program involves some 75 firms of different sizes. The explicit goal of the program is to both strengthen existing research, but also build new interdisciplinary research groups. It seeks to facilitate technology transfer from the university sector to industry, and speed up the commercialization of nanotechnology. More generally, it also aims to support networking, research mobility and participation in EU nanotechnology related programs.

The program initiated by the Academy of Finland starts in 2006 and is intended to end in 2010. The program will add another 9 million euros to public nanotechnology investments in Finland. It focuses on directed nanoscale self-assembly and functionality, as well as on properties of single nanoscale objects. In the preliminary call for proposals the program has attracted 81 research proposals with 270 individual researchers. The explicit aims of this program are to support basic nanoscientific research, facilitate interdisciplinary approaches, to develop the research environment and training in nanosciences as well as to promote mobility networking, international visibility and utilization of research results both in Finland and internationally.

4.2. Research communities

The major research and firm communities active in the field are documented in the publications by the Ministry of Education (2005) and the HelsinkiNano-project (2005). The dispersion of the communities in Finland is illustrated in Figure 7 to provide a snapshot of the regional concentration of related knowledge bases, R&D and commercialisation activities.

Figure 7. Finnish activities in nanotechnology by regions



Source: Ministry of Education 2005, HelsinkiNano 2005.

The nanotechnology research communities are typically closely associated with the technical universities. Hence, they are mainly found in the Helsinki and surrounding areas as the biggest concentration, followed by Tampere, Jyväskylä, Oulu, Turku and Joensuu with smaller concentrations. They also have differentiating focuses, ranging from self assembling materials, quantum electronics, thin layer processes, mesoscopic fermion systems, surface science, physics, virology, to aerosol research. In the following we will briefly characterize these regions and infrastructures, while turning to the related firm communities in the next section.

In Helsinki and the surrounding areas the research focus is on nanoelectronics and nanofotonics, thin layer research and atomic layer deposition techniques (ALD), integrated bio-nano-systems, nanoparticles and nanotubes, theoretical and calculatory research. The three most important actors in the Helsinki region include the University of Helsinki, the Helsinki University of Technology and the VTT. Combined these universities and research organisations host around 30 laboratories and research groups, and altogether consisting of some 200 individual researchers, some of which are associated with the Center for New Materials. These research communities account for roughly 50 percentage of the public funding for nanotechnology (HelsinkiNano 2005).

In Jyväskylä activities focus on molecular level building of systems and instruments (bottom-up), interaction between molecular level systems and environment, and research of individual molecules and nanostructures. The University of Jyväskylä has established a research centre – the Nano Science Center (NSC) – with around 100 researchers that focuses on basic research and also provides facilities for firms. The Tampere region hosts a large technical with research groups involved in optoelectronics, photochemistry, aerosol research and material processing. Examples of these areas include: quantum dot structures, solar batteries, and thin layer research (MBE). The infrastructure includes the Optoeletronics Research Center (ORC), which is related to the university and a unit of VTT focusing on material processing.

The Turku region has a history of accumulated competencies, research and firm activity in pharmaceuticals and biotechnology and most of the nanotechnology research communities appear to blend in with extant biotechnology research, e.g. biomaterial and diagnostics (cf. with Hermans and Kulvik 2006). The research infrastructure consists of two multi-department universities. In the Oulu region the University of Oulu and a unit of the VTT are focusing on the integration of nanostructures into products, especially in field of printed optics and electronics. The University of Joensuu focuses on optics and photonics, especially in diffraction grating of high efficiency and organic photocells.

4.3. Firm communities

Darby and Zucker (2003) suggest that nanotechnology-related entrepreneurship and firms activities center around 'star-scientists' due to 'natural excludability' that characterizes the field. By a first approximation the regional dispersion and focus of the different research and firms communities appears to indicate that nanotechnology developments in Finland share some similarities with these insights. In particular, firm activity in nanotechnology seems to concentrate in regions where the research base is strong and the focus of university groups match that of their business focus. Nonetheless, by and large, firm activity in nanotechnology in Finland is still fairly limited (Ministry of Education 2005).

The Helsinki region is also most visible in terms of firm communities with the number of dedicated nanotechnology firms being around a dozen, altogether employing about 300 persons. In addition, there are over 20 firms in which nanotechnology will play a key role in near future. Examples of firms include Heptagon, Liekki, OptoGaN, ABR Innova and Lumilaser. In the Jyväskylä region dedicated nanotechnology firms include Nanolabsystems and Magnasense. The Tampere region also hosts several firms that are active in nanotechnology. These include Coherent Finland, Modulight, Corelase, EpiCrystals, RefleKron, Cavitar, Oseir and Dekati. In the Joensuu and Oulu area there appears to be lesser firm activity. Scant examples include Nanocomp (Joensuu) and Braggone (Oulu).

Many of the above mentioned firms are small, and have often emerged as university spin-offs. In addition to these dedicated nanotechnology firms it is estimated that around 60-70 firms, mostly larger in size, are presently involved directly or indirectly in collaborative nanotechnology R&D projects within the FinNano-programme. This list includes such leading firms as Nokia, the pulp and paper conglomerates UPM-Kymmene and M-Real, as well as a number of medium sized firms with a growing interest in nanotechnology. It nonetheless appears to be clear that the large majority of Finnish incumbents in existing industries still await further nanotechnology developments prior to larger scale commitments. The involvement of these firms will probably be a crucial element of the application and commercialization of nanotechnology in Finland.

4.4. Publication and patenting activities

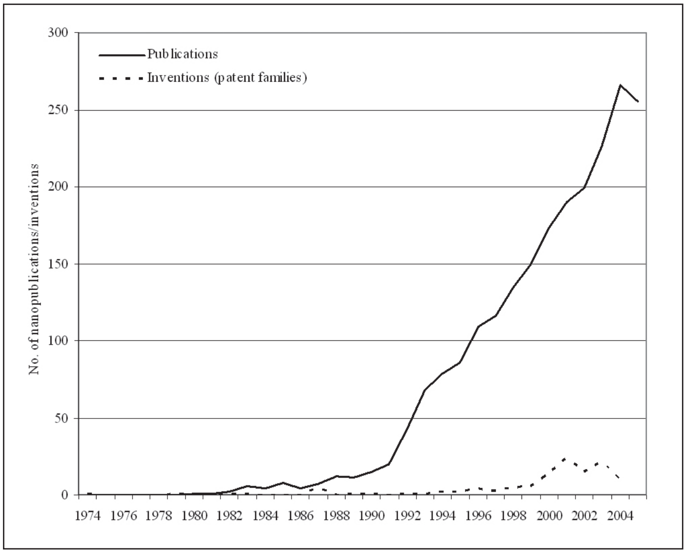
Altogether the nanotechnology keyword search algorithm that we used identified 2,259 Finnish publications and 117 inventions (patent families), all of which have been published prior to April 2006[1]. When patent families are broken down into individual patent applications and grant to specific countries we find 295 applications and 114 grants. This distribution also reflects some aspects of market developments in the sense that patents usually are sought in countries where competitors are judged as particularly strong.

Looking first at the distribution of the grants, the largest share is found in the US followed by Finland as the home country as well as Germany. Outside Europe Australia, Japan and South Korea stand out. In terms of applications – representing the most updated information - the US is in the lead followed by European countries, and Finland in particular as the home country and often the first instance for applications at the European Patent Office (EPO). Outside Europe the share of applications filed in Australia is particularly noteworthy. On closer inspection the grants and applications filed in Australia apparently relate to so-called atomic layer deposition techniques (ALD), discussed further below.

As Figure 8 shows the development of Finnish nanotechnology publications and inventions over time appears to follow world-wide trends. Significant publication activity commenced several years prior to patenting even though a couple of inventions appear already in the 1970s as an illustration of the fact that the concept nanotechnology largely also redefines research agendas that have existed for a long time. Finnish nano thus also seems to primarily be driven by nanoscience and scientists, largely exogenous to the economic system.

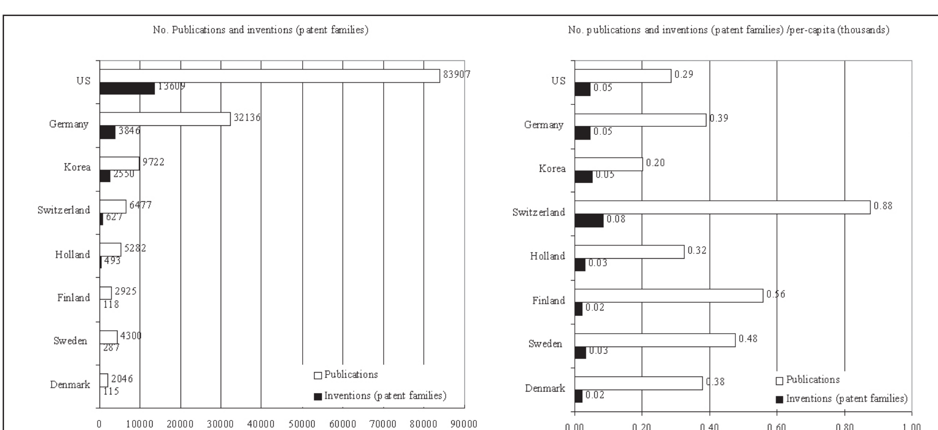
1 – The nanotechnology keyword search algorithm has been developed by the Fraunhofer Institute in Germany (see Palmberg and Nikulainen (2006)) for a detailed discussion. The Finnish nationality of patents was defined based on the country of the priority application and the affiliation of inventors. The data was provided by VTT Information Services. The patent data is extracted from the Derwent World Patent Index-database. The publications are extracted from the Scisearch-database containing a broad selection of peer reviewed science and technology journals.

Figure 8. The development of Finnish nanotechnology publications and inventions



These numbers of Finnish nanotechnology publications and inventions can be given further interpretations from an international comparison. From the estimated public nanotechnology investments we know that the volume of Finnish investments on a per capita basis is roughly similar to those in Switzerland, Holland, Germany (and France), while being somewhat higher when compared with Sweden and Denmark. In the following comparison we thus include these countries. Further, the US as the global leader, as well as South Korea and Taiwan are also interesting countries for the sake of comparison. The comparison, both in absolute and relative per capita terms, is illustrated in Figure 9, again using the same search keyword search algorithm and nationality criteria.

Figure 9. The number of nanotechnology publications and inventions across countries



By a comparison of the absolute numbers of nanotechnology publications and patent families Finland appears in the same league as Denmark while the bigger Nordic and other European countries produce significantly more. Again the dominance of the US and, Germany in Europe, is quite clear. From the more reasonable viewpoint of per-capita adjusted numbers the country size effect vanishes and the position of Finland again strengthens along with the other smaller countries, especially in terms of nanotechnology publications. Of the smaller countries Switzerland stands out, followed by Finland. In terms of patenting the numbers are still so small and do not really differentiate between countries. The overall picture that emerges is thus that Finland appears to dedicate a relatively large share of public R&D investments to R&D and that this is above all visible in a relatively noteworthy volume of nanotechnology publications. Patenting is also picking up but remains on a very low level both in absolute and relative terms, similar to most other countries.

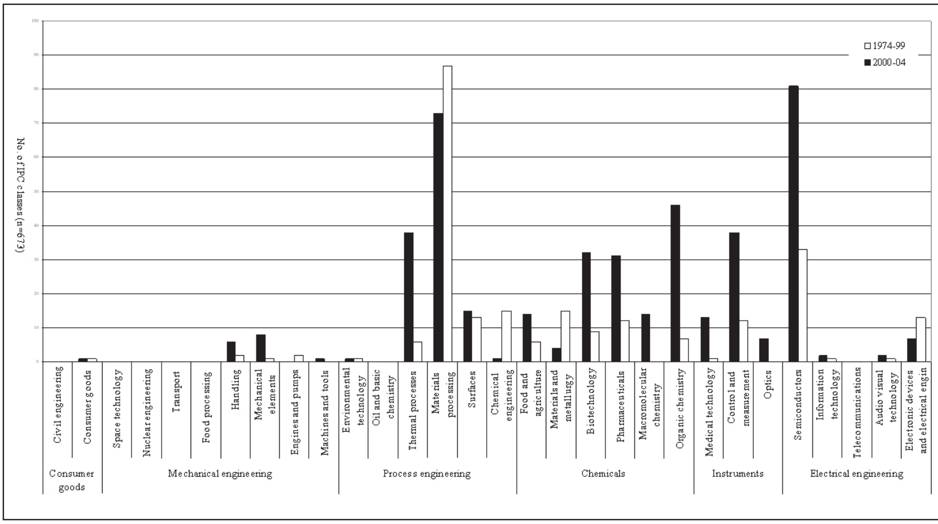
3.3. Emerging application fields

Despite the low absolute level of Finnish patenting in nanotechnology until now our data enables some analysis of emerging applications fields. The patent families are assigned to a number of main and secondary technology classes under the International Patent Classification System (IPC) at the time of application. These technology classes indicate the technological fields on which the patented invention is intended to have a bearing in terms of industrial applications. For the sake of clarity, IPC-classes are usually aggregated to higher levels of technology fields. We do this across all main and secondary IPC-classes at two levels of aggregation in the figures below based on the data on Finnish patenting in nanotechnology with reference to the technology field classification in Mancusi (2003) as a commonly used one (Figure 11).

Figure 11 suggests that most nanotechnology applications and commercialisation avenues in Finland presently relate to the broader field of process engineering. The sub-field of surfaces, thermal processes and especially materials processing stand out. The large number of patent families assigned to materials processing reflects R&D activities related to Atomic Layer Deposition techniques (ALD) and their commercialisation in the Helsinki region, and this activity appears to be the commercial spearhead of Finnish nanotechnology at present. However, the assignee of these patent is a US firm with a small R&D unit in Finland even though the origins of ALD traces back to a spin-off ventures from prominent Finnish firms in the chemicals and electronics industries in the 1970s and 1980.

Following process engineering, chemicals and pharmaceuticals appear as the second most important application field of Finnish nanotechnology and this is where the increase in the number of assigned IPC classes has been the most rapid. On a closer look, at the sub-field level, we note the increasing importance especially of organic chemistry, pharmaceuticals biotechnology. This indicates that there is some cross-pollination between nanotechnology and modern biotechnology also in Finland (cf. with Grodal and Thoma 2006). Nano- and biotechnology linkages foremost reflect emerging research and firm communities in the field of modern biotechnology in the Turku region. Beyond this the importance of electrical engineering should also be noted. This is almost solely due to the relevancy of semiconductors as an application field, although it seems that most of these applications also relate to the case of ALD.

Figure 11. Application fields of Finnish nanotechnology inventions (patent families) 1974-2004



Somewhat surprisingly, the strong Finnish specialisation in ICT does not appear to stand out in this data as the sub-fields of telecommunications and information technology are practically absent. Semiconductor applications have received some references, especially in the 1990s, but the field of electrical engineering as a whole appears to be declining in importance over time. This might be due to the lack of a significant ICT component industry in Finland.

5. A Synthesizing Discussion

5.1. General insights

This paper takes the starting point in the recent very rapid and large public R&D investments into nanotechnology worldwide. Nanotechnology is an umbrella term commonly used to refer to R&D at the 1 to 100 nanometer scale where unique phenomena enable novel applications. The interest given to nanotechnology is largely due to the perceived, and partly also over-hyped, generic nature of this field. There are strong beliefs that nanotechnology holds the potentials to renew existing manufacturing processes, products, services and industries in a revolutionary way. Nanotechnology is often referred to as a new 'general purpose technology' (GPT) which can become the next engine of growth in the world economy.

Smaller countries, such as Finland, are also investing heavily into nanotechnology even though the field is still in a very fluid and uncertain phase of development and lacking clear indication of application fields, commercialisation avenues, industrial dynamics and organisation. Accordingly there is a need to shed more light on nanotechnology also from the viewpoint of the economics of technological change to support innovation policy and firm strategies. Conceptually the literature on GPTs – with its Scumpeterian and evolutionary economics connotations – appears useful in this context even though it is far from clear that nanotechnology will evolve into one itself, especially in its present form. The concept is clarifying by highlighting some main criteria that a technology has to converge to in order to become a GPT. When these criteria are assessed from the viewpoint of nanotechnology some policy-relevant observations might be made.

By the first criterion, nanotechnology is indeed characterised by significant scope for improvement along economically relevant dimensions of merit as the first necessary, albeit not sufficient, criterion of a GPT. This is indicated by the acceleration of nanotechnology-related patenting. Moreover, a few larger countries dominate patenting and thus appear as the technological leaders. Thus, nanotechnology appears to follow a similar development path as modern biotechnology has taken before. The second criterion of the widening use of a GPT over time also appears to fit. Nanotechnology is significantly more generic and could be more application oriented than modern biotechnology. As such it might best be compared to ICT. However, it is clear that the concept 'nanotechnology' also largely redefines previous research agendas in the fields of physics and chemistry, as well as biotechnology, and is thus analytically quite ambiguous.

The present core of nanotechnology is the ability to manipulate molecules so that every atom can be put in its most efficient place to achieve a particular functionality. Nanotechnology is thus essentially a new production method with multipurpose functions. Nonetheless, the degree to which the third criterion of multipurpose usage will be fulfilled largely depends on when and where such 'bottom up' nanoscale engineering techniques become available on an industrially viable scale and achieves complementarities with technologies and innovations in related fields to fulfil the fourth criterion of a GPT. A comparison with ICT and modern biotechnology suggests that many technological, structural and institutional hurdles still lie ahead. The greatest potentials of nanotechnology probably lie in crossovers to existing technologies, firms and industries.

GPTs might emerge exogenously to the economic system but they have to become endogenous in order to have their longer-term growth effects. In the light of developments over time of nanotechnology-related publications (as rough proxies for scientific developments) and patenting (as rough proxies for technological developments), it seems that nanotechnology still largely incubates in the university sector as "nanoscience", largely exogenous to the economic system. Further, in cases where firms are involved their innovation activities largely appear to draw heavily on scientific research at universities. A topical issue is how nanoscience can be transferred to more widespread use in industry and to what degree the specificities of nanotechnology offers new challenges in this context? These specificities foremost seem to relate to the interdisciplinary nature of the field, to the actual identification of the object of technology transfer both in terms of artefacts and different types of knowledge, as well as to uncertain and longish product development times. The interdisciplinary nature of nanotechnology also suggests that technological gatekeepers, as well as the involvement of scientists in firm activity, is important.

In addition to issues related to technology transfer, an important question is whether large incumbent firms or small new entrants will be the main carriers of commercially viable nanotechnology. Traditional models of industrial dynamics and organisation highlight the role of new entrants in the emerging phases of a new technology, although elaborations of this basic framework also are to be found. As nanotechnology largely also redefines previous R&D agendas and, especially in its 'top-down' approach to nanoscale engineering, also has complementarities with existing manufacturing methods, there are viable reasons to believe that it is more likely to enhance rather than destroy knowledge bases of incumbent firms. In practice a symbiotic co-existence of new dedicated nanotechnology entrant firms and established incumbents is also quite likely as new niche markets in such fields as intermediate nanoscale components and nanotools are emerging. Nonetheless, if and when 'bottom-up' approaches to nanoscale engineering become industrially viable in the unforeseeable future they might also have a quite destructive impact on established incumbent firms and countries.

5.2. The case of Finland

Naturally Finnish public R&D investments into nanotechnology only account for a miniscule share of global investments. In a European comparison these investments are at similar absolute levels as in the other small countries Ireland, Sweden and Belgium even though Finland appears to stand-out amongst this reference group on a per-capita basis. Partly this might be due to the general high dedication given to R&D which also spills over to nanotechnology due to the interdisciplinary nature of this field. However, Finland has also recently initiated two dedicated nanotechnology programs with relatively large volumes, implying a noteworthy boost in public R&D investments. Nanotechnology has also been supported before albeit under other labels as a part of biotechnology and materials R&D.

At present research and firms communities are entering, or emerging, in nanotechnology-related fields in close vicinity to the main universities in Finland. Accordingly, there seems to be a certain degree of regional clustering of activities and the role of scientist in firm activities, as well as university spin-offs, appears to be important. Nonetheless, the community of dedicated nanotechnology firms is still small and a relatively large number of these are extant biotechnology firms due to cross-pollination between nanotechnology and modern biotechnology. The biggest concentration of research and firm activity is found in the Helsinki region where the Helsinki University and the Helsinki University of Technology play an important role, along with the Technical Research Centre of Finland (VTT). Some 60-70 larger firms are also showing variable interest in nanotechnology but these incumbents largely still await further developments prior to larger scale commitments.

Publication and patent (patent families) data was used to analyse publication and patenting activities of Finnish nanotechnology-related researchers, inventors and firms, to identify emerging industrial dynamics and organisation, as well as application areas. This data was identified through an elaborate search algorithm based on nanotechnology keywords. In a country comparison the position of Finland in terms of public R&D investments also appears to be reflected further downstream, especially in the number of publications. The level of Finnish nanotechnology publication activity is similar to that of some significantly bigger countries on a per-capita basis. These smaller countries also appear to perform relatively well when compared with the US and Germany.

On closer inspection it is clear that publication activity on a noteworthy scale started much earlier than patenting, and that also Finnish nanotechnology primarily is driven by scientific developments. In terms of application fields Finnish nanotechnology patents foremost appear to have a bearing in the fields of process engineering and chemicals. Individual application sub-fields that stand out within these broader fields include semiconductors, materials processing, pharmaceuticals and biotechnology, with a noteworthy growth especially in the latter sub-fields. Perhaps somewhat surprisingly the sub-fields of telecommunications and information technology are not really visible even though Finland is highly specialised in ICT.

By and large the analysis of nanotechnology publications and patents is in line with what the descriptive account of existing and emerging research and firm communities suggests.

Given the competitive position that Finland has in many of the more traditional forest-related, engineering, metals and ICT industries, a key issue of importance to the potentials that nanotechnology might have to renew industries and promote growth in Finland is the degree to which incumbent firms also will take an interest at an early phase. Apart from approaching the commercialization of nanotechnology from this viewpoint, the possible specificities of this field from the viewpoint of technology transfer from universities to industry should also be considered.

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V. LEARNING TO DESTROY: CASE STUDIES OF CREATIVE DESTRUCTION MANAGEMENT IN THE NEW EUROPE

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Abstract

Capitalist systems of production provide a fascinating and dynamic but at the same time highly problematic method of bringing about socioeconomic change. Capitalist systems tend to produce a variety of goods and services that are successfully marketed and sold, but which are in reality not always very useful to people and organizations and which in many cases may bring more harm and unhappiness than it brings positive effects. And even when they do not bring explicit harm and unhappiness, many products appear questionable because they are often vastly inferior in their functions and quality to existing and price worthy alternatives – alternatives that for one or the other reason do not manage to reach out to the users. The current article looks at the creative destruction of banking technologies, old-generation nuclear power stations, copper-wire telephone lines and fossil-fuel energy production.

1. Introduction: We Live in a World of Crap

In an era obsessed with issues related to economic development and globalization, it is perhaps unnecessary to point out that our capitalist systems of production provide a fascinating and dynamic but at the same time highly problematic method of bringing about socioeconomic change. Far-reaching objections against capitalism have focused above all on the ever increasing brutality of competition, especially in our dramatically globalizing era, with its many severely negative effects on people's lives and well-being in a variety of dimensions. Following the Marxian legacy there is a fear – or hope! – that this will lead to social upheavals and ultimately political revolutions that would undermine the institutional foundations of the capitalist system. The argument recalls Schumpeter's (1942) own doubts as to whether capitalism would be able to survive on the long-term.

In this chapter, however, we will discuss a somewhat different but largely neglected issue in capitalism's inherent problems. It takes as its point of departure the observation that capitalist systems tend to produce a variety of goods and services that are successfully marketed and sold, but which are in reality not always very useful to people and organizations and which in many cases may bring more harm and unhappiness than it brings positive effects. And even when they don't bring explicit harm and unhappiness, many products appear questionable because they are often vastly inferior in their functions and quality to existing and price worthy alternatives – alternatives that for one or the other reason do not manage to reach out to the users.

Looking at the shelves of hypermarkets and the endless rows of shops in our cities, and browsing the vast varieties of virtual market places, only very few things seem to us truly useful and beneficial. Especially in the richest countries in the world, most of the things that are being bought are products that people could easily live without, while still being at least as happy as before. We buy vast amounts of unhealthy food which makes us fat and sick, alcohol and tobacco that make us drunk and addicted, cars that destroy our environment, pharmaceuticals that do not improve our health, we build wind turbines and transmission lines that destroy our landscapes, move into houses that are terribly ugly, fly airplanes that are bound to crash, watch senseless movies and TV programmes, buy and sell weapons to kill our fellow citizens, etc. In a sense it seems reasonable to say that we will in a world full of crap.

This aspect of capitalism may seem natural, like a necessary evil and a price we have to pay if we want to enjoy the benefits of the same system. Ironically, the production of crap can be seen to contribute heavily to the accumulation of wealth in capitalist countries, because it is to a great extent exactly the income from selling crap that gives many of us the opportunity to buy more useful goods and services and hence improve our well-being. This may – at least in democratic countries – make it politically difficult to engage in a process aiming at limiting or decreasing the economy's production of crap. It is a dilemma that highlights the difficulties, from a political point of view, of managing creative destruction, pointing at the need not only to perpetually create ever new products and processes in the evolving economy, but also and above all to enable the removal and destruction of obsolete things.

In fact, it is by no means clear that the main challenge for the innovative capitalist economy is to *create new innovations* – it may very well be that the more difficult task is to find mechanisms to *get rid of old crap*, since it is often the superfluous existence of old crap that actually hinders more useful innovations from being created and diffusing effectively in the marketplace. As already mentioned, many old and obviously outdated products and processes continue to be extremely dominant in the economy *despite* the existence of new, better and economically viable alternatives. If those outdated things could be effectively removed, the diffusion of better innovations would obviously become much easier and more effective. From this perspective creative destruction management is very much a challenge of learning to destroy.

2. The Baltic Sea Region as an East-West Arena for Creative Destruction

While we might use theories of innovation to speculate in a deductive way about what the most effective political means of getting rid of old crap and creating room for new and better products and processes are, we will in this chapter briefly discuss how the corresponding processes have actually taken place in a number of cases. An interesting question is thereby whether some countries can be seen to be more successful than others at managing creative destruction in this sense of the concept, and if so, why? A related question is then also how other countries can learn from success stories, i.e. whether and how countries with a weak performance in creative destruction can improve their performance and become more efficient by learning from more successful countries?

The Baltic Sea region seems to provide an excellent field for studying how creative destruction has been managed in countries with different types of political and economic systems. All countries in the region can presently be labelled capitalist countries, but the region contains both small and large countries and above all it contains countries with very different historical paths of development.

Let us here focus first and foremost on the East-West divide in the region. With ‘Eastern’ countries I mean those countries in the region which until recently were part of the Soviet Union or communist Central and Eastern Europe, i.e. Estonia, Latvia, Lithuania, Poland, East Germany and Russia. With ‘Western’ countries I mean countries that for a longer time have been part of the capitalist world, i.e. Sweden, Finland, Denmark and West Germany. The East-West divide in this sense provides an intriguing possibility to investigate the ways in which the political discontinuity (cf. earlier chapter in this volume) in the East following the collapse of the Soviet Union have created opportunities for more radical creative destruction. In earlier research on innovation it has been hypothesized that newly industrializing countries might be able to ‘leapfrog’ the more advanced countries in some technological transitions (Perez and Soete 1988), as a consequence of the former’s lacking the often problematic historic inertia of the latter countries. In Eastern Europe, the situation is somewhat different from that of developing countries, as this region is not ‘newly industrializing’, but has already a long industrial history. But the radicality of the systems change in the years around 1990 begs the hypothesis that the political revolution opened up a window of opportunity with respect to necessary destruction processes. Such a window of opportunity could at least theoretically lead to a competitive advantage in some respects for the East, since the same destruction processes in the West would be much more difficult to realize in countries with a more stable societal development.

Hence, the main purpose of this paper is to investigate whether the Eastern countries in the Baltic Sea region have been able to take advantage of their unique historic position after the collapse of socialism, and use it for effective creative destruction management.

3. Enabling Destruction: Four Case Studies

The cases selected below focus on creative destruction challenges in the period from the 1980s and up to today. Out of four cases in total, two are from the ICT sector and two from the energy sector.

Case 1: Getting rid of outdated banking technologies

In the early 1990s, banking services in the capitalist world were still almost exclusively based on manual solutions based on century-old innovations such as cheque and giro systems which were widely diffused and extremely popular in the marketplace. Banking was, as most service industries at that time, very much a traditional ‘supplier-dominated’ industry (cf. Pavitt 1984). Since the 1960s banks had taken an interest in computer technologies for internal processing, but this was something that the customers rarely came in direct contact with. In the communist countries, banking was considered a peripheral activity in society and lagged behind the developments in the West. For example, Eastern countries typically lacked the cheque system, and wages were often paid out in cash, while in order to pay bills one had to visit the office of the payment receiver.

In the late 1980s and early 1990s, banking service innovations in the West focused on such areas as ATMs (‘cash machines’), off-line computer banking and not least computerized telephone banking. Especially in Western countries, banks invested heavily in the development of telephone services for the mass of their private customers, foreseeing that enormous cost-cuts could be achieved if a range of traditional banking services could be performed automatically with the help of machines that guided customers, instead of customers visiting the bank's physical offices. Telephone banking was in this sense a process innovation, i.e. offering more or less the same service products as earlier but in a new way, i.e. with the help of new technology.

In the mid-1990s, however, when the world wide web and the first useful web browsers had been invented, some banks started get interested in an alternative service paradigm to telephone banking. The idea was to enable banking customers to buy banking services over the Internet. It was a magnificent idea that seemed to have the potential to conquer the entire computerized world's banking markets. However, the Internet banking enthusiasts faced a tougher way forward than they had expected. One reason was, as in so many other cases when fabulous new technologies emerge, that the invention was initially very crude and did not work well and reliably. In particular, there were technical and institutional obstacles related to information security that would have to be solved. Another and probably more important reason for the difficulties, was that most banks in the West had already invested large amounts in the older telephone-based technological path. For them, Internet banking represented a competing trajectory and therefore a threat, and they were extremely reluctant to give up their activities in their existing field. In addition, the existence of reliable old-style banking solutions (cheques, giro, etc.) meant that it was not necessarily imperative to advance quickly towards Internet-based services.

In Estonia, however, a former Soviet republic that was in the mid-1990s still an extremely poor country where the main banks had not yet had time or financial resources to invest heavily into telephone banking, and where the entire banking industry was still in its very infancy, the development was surprisingly different. Some banks that were essentially recent start-ups decided to offer their customers online Internet banking solutions without hesitation, starting already in spring 1996 (*Baltic IT Review*, no. 2, 1996, 36). This was much earlier than corresponding developments in many Western countries, including Sweden, where the banks behaved much more carefully and conservatively with respect to the new Internet opportunities. By 2002, around 25 percent of Estonians were already using Internet banking services actively, whereas in most West and South European countries the penetration was around 10 percent. Especially in the US, where the cheque system remains extremely dominant today, the penetration was no more than 4 percent. The Nordic countries, on the other hand, had managed to catch up with Estonia, riding on their high overall Internet penetration ratios (Kerem 2003, 20).

With hindsight, it is perhaps not the rapid growth in Internet banking in Estonia, outpacing most of the much richer Western countries, that was the most striking aspect. With its enthusiasm for the Internet in general, a liberal policy with respect to competition in the banking sector and strong inherited competencies from the Soviet era in the field of ICT, it is hardly surprising that Estonia achieved this success. It was hardly anything that the government had to 'manage'. On the contrary, the success in Internet banking inspired government agencies to initiate creative innovation in Internet-based public services! (Högselius 2005a). The main point, instead, is the obvious inertia and difficulties faced by Internet banking proponents in most Western countries. In Sweden and Finland, which form two exceptions in the West, healthy competition in the banking sector in combination with a strong Internet penetration seems to have paved the way for a relatively swift introduction and diffusion of Internet banking after the initially conservative hesitation. But in countries such as Great Britain, France, Germany, Italy, the Netherlands and in particular the United States – that is, technologically advanced countries that certainly did not lack the necessary competencies to engage in Internet banking development – it turned out to be extremely difficult for the new services to diffuse in the marketplace. The reason was obviously that the already existing, though technologically outdated alternatives had very deep roots in the daily routines of the masses and that they were seen to function smoothly, i.e. there was no radical need for improvement from the perspective of the users.

Case 2: Shutting down old-generation nuclear power stations

Nuclear power is a technology that has been hotly debated since the 1970s. This has been so especially in the Western world, where the political systems traditionally allowed a much higher degree of public controversy, as compared to communist Eastern Europe. Nuclear power has been viewed by the most enthusiastic proponents as a more or less universal solution to virtually any societal problem, whereas among its opponents nuclear power has been portrayed as a disastrous threat to human civilization (cf. Anshelm 1999).

Not least in response to the critical arguments against nuclear power, nuclear scientists and engineers have been strongly inspired to pursue far-reaching and radical innovation in their field, seeking to create more efficient and increasingly secure nuclear power plants. The same goes for the variety of technologies that belong to the 'nuclear fuel cycle', such as uranium mining, fuel element fabrication, reprocessing technologies, nuclear waste management, transmutation of spent nuclear fuel, etc. In the field of nuclear reactors, impressive new reactor types have been developed, many of which have characteristics that make them radically different from early-generations nuclear power. However, the new generation of reactor models have so far failed to conquer the market for power plants, and the market thus continues to be dominated by early-generations nuclear power plants and conventional power production facilities, particularly based on fossil fuel.

Obviously the new, modern nuclear power technologies would find it easier to achieve a market breakthrough if the older and basically outdated power plants (typically constructed in the 1960s and 1970s) that are now still dominant could be removed from the energy system. Of course, not everybody would agree with the statement that the existing nuclear power plants are 'outdated', as they have often been continuously modernized. For example, the analogue control systems from the 1960s and 1970s have usually been replaced by digital control, which contributes to leveraging security, and the electric effects of many reactors have been successfully increased. However, these innovations still follow a technological path defined by the basic underlying technologies developed about half a century ago, and the actual improvements can be considered relatively minor compared to the much more radical innovations going on in new-generation nuclear reactor technologies.

In fact, some countries have politically tried to get rid of their old nuclear power stations. However, Italy is so far the only country that has actually fully decommissioned all of its old-style nuclear power. In countries such as Sweden and West Germany, political decisions have been taken that all nuclear power shall be phased out, but in reality this has not happened, and nowadays the public opinion in these countries has shifted to being increasingly positive to the continued utilization of the old nuclear power plants. The nuclear power plants are often viewed as the 'least evil' in an energy system where the alternatives are above all power plants based on fossil fuel. Hence, creative destruction management in the field of nuclear power can only be described as a great failure in the Western world. To be sure, this interpretation does not mean that the old nuclear power reactors have not undergone significant improvements over the years, but it is certainly not possible to speak of any paradigm shift in nuclear power.

Some countries in Eastern Europe, however, seem to have been more successful when it comes to destroying its outdated nuclear power reactors. The most obvious example is perhaps East Germany, which still in the late 1980s had an extremely ambitious nuclear power programme, based on early-generation Soviet reactors. Immediately following reunification with Western Germany, however, the entire set of nuclear power reactors were shut down, following a central political decision. Unfortunately, however, this successful destruction of the old-style reactors does not appear to have been creative, as the nuclear reactors have not been replaced by new and modern power plants, but rather by *other* types of old-fashioned power production facilities (especially lignite-fired power plants – see further case 4 below) (Högselius 2005b). This is highly regrettable, and it points at the need to combine destructive efforts with other, related policy measures to make the destruction creative.

Another interesting example in the Baltic Sea region is Lithuania's nuclear power. Lithuania's attempts at destroying its nuclear power system is historically closely linked to its independence movement in the late 1980s, when the nuclear power reactors at Ignalina were viewed as symbols of Soviet occupation of the country. After independence had been regained, the Lithuanians became more positive towards its nuclear power plants (Dawson 1996). However, neighbouring countries and in particular the European Union remained extremely critical to Lithuania's Soviet-designed reactors, which were of the same type as the infamous Chernobyl reactors in Ukraine. In the negotiations about EU accession in the years around 2000, the EU made the shut-down of the Ignalina reactors a condition for EU membership. Hence, the first reactor was forcefully shut down at the end of December, 2004, and the second and last reactor is hoped to be shut-down by 2009.

The least successful country in the Baltic Sea region in the nuclear power case is Finland. This country decided not to shut-down its old-style power plants in Loviisa and Olkiluoto, but, on the contrary, recently opted for the construction of a *new* nuclear power reactor, which will be more modern than the older ones but still basically belonging to an early-generation nuclear power paradigm.

Case 3: Replacing copper-wire telephone lines

Telecommunications is a sector that have undergone several radical technological shifts in its history, starting with the establishment of telegraph lines in the mid-19th century and currently adapting itself to Internet-based communications. The recent changes in relation to the Internet are so radical that the very concept of 'telecommunications' has become diffuse and difficult to grasp. However, a peculiar feature of the ongoing disruptive development is that the basic copper-wire infrastructure of fixed telecom networks has retained many of its original, 19th-century characteristics. Especially with respect to the 'local loop' or the 'last mile' that connects local exchanges to the user's premises, the copper-wire infrastructure with its origins in the 19th century remains tremendously dominant.

On the long term, this will almost certainly lead to big problems, because the primitive physical properties of the copper wire makes it difficult to use it for super-fast Internet access. From this perspective, it would appear desirable to substitute more modern types of cables for the copper wire, preferably by installing optical fibres to the end user ('Fibre To The Premises', FTTP). Such a replacement would mean a powerful case of creative destruction of a century-old technology in telecommunications and would create virtually infinite opportunities for Internet users.

In the late 1980s and early 1990s, these ideas created a series of visionary debates in the world of telecommunications, and it appeared obvious that FTTP would soon be put into practice on a grand scale. In the Baltic Sea region, the most impressive and offensive visions that emerged against this background was the attempts in Eastern Germany in the early 1990s to replace the outdated telephone infrastructure inherited from the socialist era with FTTP, i.e. the most advanced telecommunications infrastructure available. The old copper-wire infrastructure was in many parts of Eastern Germany in such bad shape (and often it was even non-existing) that it was not deemed economically viable to renovate it, especially not in view of the Internet era that was approaching. Therefore, totally new lines would have to be created. DBP Telekom, the merged East-West German incumbent network operator, had in mind to implement optical fibre in the local networks all over the ex-GDR, which, if realized, would indeed have been a fantastic achievement.

However, the imagined technological revolution experienced severe competition with other societal goals. The Internet was at this time still unknown to most people, who hardly used any data communications services at all, and the priority therefore shifted to realizing the more basic needs of simple voice services. DBP Telekom was under severe time pressure, and in that situation it preferred to use almost exclusively very well-known (i.e. old) technologies and solutions. The risk of bringing in new technology was interpreted as being too high. Therefore, DBP Telekom in reality installed not optical fibres, but mostly new copper wire in the local loop. The initially grand plans were reduced to a pilot project that in the end connected 1.2 million homes and businesses in Eastern Germany with optical fibre (which can nevertheless be considered a substantial achievement for the time!) (Neumann and Schnöring 1994, 330).

The East German situation resembled the problematic point of departure for other post-socialist countries. However, East Germany was special among the ex-socialist countries in the sense that it had access to enormous amounts of funds for investment, originating in Western Germany. Other East European countries could never dream of any large-scale FTTP projects. At the same time, in most Western countries, the existence of well-kept copper-wire infrastructure and the substantial costs of installing FTTP meant that these countries remained hesitant to local loop fibre investments. This situation inspired traditional telecommunications equipment manufacturers, such as Ericsson, Siemens and Nokia, together with their incumbent partners among telecom network operators, to innovate seriously in data communications technologies based on the existing copper wire infrastructure. Creating copper wire broadband technology – more commonly known as DSL – turned out to be a very successful way to defend vested interests in the old-style telecom infrastructure. While it has always been obvious that FTTP would offer vastly superior bandwidth, DSL solutions appeared to be ‘enough’ for most users, at least for the time being. In particular, DSL appeared to be much cheaper than FTTP, and nowadays DSL is most countries the clearly most dominant broadband technology.

Countries where FTTP has been relatively successful include Japan, Sweden and the Netherlands (*Telecommunications International*, July 2005, 12). Driving forces in the development there seem to have been far-sighted visions of the information society in combination with a long-term preparedness to invest from both the private and the public side. In Sweden, for example, the creation of a fibre-network infrastructure has been compared to the country’s historical success in establishing railway and electricity systems. However, most countries are still today very far away from a dominance of the optical-fibre local loop. While fashionable business districts and universities (with dense layers of Internet users who can pay for the corresponding service) have generally installed optical fibres in the local loop, normal residential areas in cities and in particular rural areas have today generally no hope of getting connected with this modern technology. The main reason is still the enormous costs associated with installing FTTP infrastructure, and the success of DSL and cable-TV solutions.

In other words, creative destruction in the local loop has generally not taken place, but the development has rather been one of creative accumulation, favouring old innovators which can continue to build on century-old technologies and competencies. It may appear paradoxical that such an old-style artefact as the twisted pair of copper wires have survived so successfully into the cyberspace era. Moreover, it risks leading to lock-in situations in the future, with many dominant service providers having invested heavily into improving the copper-wire infrastructure rather than replacing it.

Case 4: Putting an end to fossil-fuel energy production

Electricity and heat production through the combustion of coal, oil, gas and other fossil fuels poses a great threat to the environment. Traditionally, these threats were considered linked with the emission of sulphur and nitrogen oxides into the atmosphere, leading to the destruction of the landscapes in regions surrounding power plants. Environmental innovation managed to solve the lion-share of these problems during the last couple of decades, but in the 1980s, attention focused towards a new type of fossil fuel-based environmental concern: the green-house effect. Due to the enormous amounts of carbon dioxide emitted into the atmosphere by fossil-fuel power plants, it is being increasingly recognized that these technologies are something that we had better get rid of once and for all.

However, creative destruction in this field has turned out to be tremendously difficult. Fossil-fuel power production has deep roots and traditions in many countries, and it is often seen to guarantee domestic self-sufficiency of electric energy and heat. The available new power production technologies – such as solar energy, new-generation nuclear power and various forms of renewable energy – are as a rule politically highly controversial and/or still technologically crude and therefore expensive.

In many East European countries, the collapse of socialism was in this context seen as a major chance for enabling the shut-down of a vast number of old, heavily polluting fossil-fuel power plants, and replacing them with more modern forms of electricity production. An interesting case is Estonia, where the overwhelming public objection against the expansion of oil-shale-based power production became part of the national liberation movement in the late 1980s. Oil-shale power production was seen by the Estonians as a symbol of centralized Soviet power, and the heavy pollution and low energy economy of the corresponding power facilities seemed to embody the evil of the occupation power. A special feature of the Estonian power production system was also that it produced a vast over-supply of electricity, which was exported to neighbouring Soviet republics, such as Russia and Latvia. From the Estonian national perspective this was seen as unnecessary, leading to an over-exploitation of its domestic natural resources and severe pollution (which was not exported) (Högselius 2006).

Having regained national independence, however, the new political leadership in the tiny republic re-interpreted the status of the large Soviet-built oil-shale power plants. The export of electric energy to Russia, Latvia and other countries was now seen as an important source of income, and this was considered more important than the environmental threats. Therefore, the power plants were not shut-down, but, on the contrary, refurbished with modern environmental technology, hence preparing the facilities for a prolonged life in independent Estonia. Moreover, the continued existence of a vast over-supply of electricity domestically most probably contributed strongly to halting a technological shift towards more modern power production techniques. In the end, the initial dreams of a radical technological transition and creative destruction in the field of energy have therefore not come true in Estonia.

A related development can be observed in Eastern Germany. The East German energy system was in the late 1980s based first and foremost on lignite (brown coal) and to a lesser extent on nuclear power. In contrast to Estonia, East Germany did not have any vast oversupply of electricity, but the collapse of the socialist economy after the fall of the Berlin wall led to a dramatic fall in industrial electricity consumption. This made it possible to shut-down all nuclear power reactors in the country within a year (as described in the case study on nuclear power above), without risking electricity outages or facing an import need. Some of the oldest lignite-fired power plants were actually shut down in this connection. Great visions flourished for a few years following the fall of the Berlin wall, with the idea that the radical political change in combination with access to West German capital would enable a complete and radical renewal of the East German energy system. It was argued that East Germany had the potential to become the most modern and environmental-friendly energy country in the world, if just the hopelessly outdated lignite power plants could be shut down and replaced by alternative sources of energy (Högselius 2005b).

However, as in the case of Estonia, these visions were never realized. Political pressure was strong to retain lignite-based electricity production, as this sector was an important employer in East Germany and all competencies of the power companies was focused on lignite. Moreover, the existing structure of the East German electricity sector also fitted well with the West German experiences, where coal and lignite were similarly very important sources of energy. The unique opportunity to radically create something new, while decommissioning the old system, was in the end seen as too risky in several dimensions. Instead, all efforts were directed towards refurbishing the remaining lignite-fired power plants, applying modern environmental and control technologies, and there were even some new lignite-based power plants being erected. The technological trajectory from the GDR times was thus not given up, but rather strengthened.

4. Discussion and Conclusions: Can We Learn to Destroy?

Having investigated four challenging cases of creative destruction efforts in a variety of European countries, let us now return to the question of whether some countries can be considered better than others at managing creative destruction, and in particular whether the Eastern countries in the Baltic Sea region have managed to take advantage of their lack of inertia for leveraging this process.

The most obvious conclusion that can be drawn from the above case studies is that it has been tremendously difficult to manage creative destruction all over the Baltic Sea region, including both Eastern and Western countries. Moreover, it is hardly possible to draw any clear conclusion concerning which part of the Baltic Sea region – East or West – has been more successful at managing creative destruction.

As could be expected, the main difficulties in the West are closely related to the high level of development and diffusion of already existing, older technologies, which means that these countries have a lot to lose when facing the challenge of radical technological change. Therefore they often hesitate to jump into the new technological paradigms even if they recognize the strengths of the new technology and do have the necessary competencies, financial resources, institutional capabilities, etc. The case of Internet banking illustrated this dilemma in a clear way. The inertia in already advanced countries can be extremely strong, as in the case of nuclear power, where in some countries clear political decisions were made to get rid of the outdated technology, but with no result. Politics was here the prisoner of a vast techno-political complex and its momentum.

In the case of telecommunications, the West seems to have missed a chance to install optical fibres to the end user (FTTP) on a grand scale, leaving the victory to traditional copper lovers such as old equipment suppliers and incumbent network operators, where the 19th century-based copper wire has now been updated to DSL. On the surface, this appears to be a matter of the enormous costs of the more visionary FTTP technology. However, some governments, notably in Sweden, have shown that it is possible to support FTTP diffusion through intricate public-private partnerships or other institutional mechanisms. East Germany, too, formulated extremely brave goals with regard to telecommunications following Germany's reunification, and although the initial vision of installing optical fibres to all users in East Germany was not realized, the pilot project of 1.2 million users can in itself be regarded as relatively successful.

In the East, the major problems are typically of a somewhat different kind as compared to the West. The removal of historical inertia in many sectors following the collapse of socialism made it more tempting here to try out a creatively destructive path, but this circumstance was often counterbalanced by problems relating to funding, as illustrated in the telecommunications and fossil-fuel cases. The weak financial status of the 'new' countries in the East shortened the visionary horizons of policymakers and other actors in these cases.

On the other hand, it is in the East that we actually do find some of the most interesting success stories when it comes to getting rid of old crap. For example, the Eastern part of the Baltic Sea region is now almost totally liberated from old-style nuclear power, and in the Baltic states consumers hardly have an idea anymore of old-style banking methods such as cheques and giros. The East has thereby actually managed to get rid of technological antiquities that will probably continue to plague most Western countries for decades or generations.

Notably, however, the success in the East cannot be described as a result of domestic policymaking or state action. Internet banking inspired rather than was inspired by policymakers, and nuclear power shut-down was managed per decree by foreign political bodies such as West Germany (in the East German case) and the EU (in the Lithuanian case). This seems to point at a need to approach the challenge of creative destruction management as a transnational political issue rather than as an isolated domestic challenge.

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VI. TRANSFORMATION OF INNOVATION SYSTEM IN A SMALL COUNTRY – THE CASE OF FINLAND

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Abstract

The chapter analyses the evolution of Finnish science and technology policy from mid-1960s until recent days. Special emphasis is laid on developments since early 1990s. In a less than a decade the country became one of the leading information societies and knowledge-based economies in the world. The resurgence from the deep recession of the early 1990s is in considerable part attributable to the developments in the information and communication technology (ICT) sector. Our particular research topic here is how Finland became a success story in ICT. The basic argument of the chapter is that a "Finnish model" of information society or science and technology policy was not created in the years of rapid growth of the 1990s. There was no "master plan" prepared in the early nineties to restructure the Finnish economy. The success came rather as a result of a series of policy measures over a longer period. They were working in the same direction and produced effect partly in the 1990s. There were also complementarities between policies, financial market liberalisation, and legal restructuring. Hence, as a society Finland was relatively well positioned when the opportunity came.

1. Introduction[1]

During the ICT boom of the 1990s Finland deserved the reputation of one of the leading information societies, a country of economic dynamism and high level of social security at the same time. International comparisons ranked Finland as one of the most competitive and most technologically developed knowledge-based economies in the world[2]. While competitive technology-driven economy and high level of social cohesion are often seen as antagonists, the Finnish developments in the 1990s seem to indicate that they can be combined. Castells and Himanen (2002) introduced a concept of "informational welfare state", i.e. the Finnish model of information society.

In the early 1990s the country's prospects seemed much gloomier. In 1990 Finland was hit by the most severe economic crisis in any OECD country since World War II. Real GDP dropped within three years by more than ten percent and unemployment rate quadrupled to 17 per cent. The country with the lowest unemployment rate of OECD in 1989, was among the worst performers only a couple of years later (Honkapohja and Koskela 1999; Kalela *et al.* 2001). Numerous

1 – There are numerous reports on the Finnish economic and social transformation since the early 1990s. Some parts of this paper draw on Georghiou, Smith, Toivanen and Ylä-Anttila (2003), and Rouvinen and Ylä-Anttila (2003).
2 – WEF – World Economic Forum has ranked Finland four times as number one in its Competitiveness Index during the twenty-first century, and the WEF Global Information Technology Report 2002-2003 the most developed IT society. IMD (Institute for Management Development) World Competitiveness Yearbook 2003 ranks Finland number one in the group of smaller countries. Global International Technology-Economy Index - GITEI (by Department of Computer Science, Stanford University) places the country second overall among some 50 countries surveyed worldwide.

factors contributed to the crisis: downturn in the nationally vital forest-related industries; disruption in the country's sizable eastern trade with the collapse of the Soviet Union; speculative bubble in the domestic securities and real estate markets fuelled by uncontrolled credit expansion and favorable terms of trade; and mismanaged financial liberalisation, eventually leading to credit crunch and excessive private sector indebtedness.

After the deep recession the country however achieved a strong recovery in the course of which the economy and society underwent a major restructuring at various levels. Overcoming the crisis is a crucial turning point in understanding the transformation of the latter part of the 1990s. In a decade Finland has progressed from being one of the least ICT specialised countries to an undisputed champion in the field.

The key factor was adaptability and common acceptance of change. It seems that the country as a whole, its policy mechanism, and most economic actors were able to adjust and make use of opportunities offered by the new technologies. So the situation moved from stagnation to industrial transformation and growth. The question then arises: Is there something specific in the national innovation system that has produced success stories like Nokia and Linux? Did it all happen just in a decade? Do the Finnish experiences bear lessons to other countries?

In what follows we examine the phases of industrial development in Finland and highlight the role of science and technology policies (section 2). Our basic argument is that a "Finnish model" of information society or science and technology policy has to be traced down in a longer historical perspective, in any case earlier than the 1990s, if one wants to understand how it took shape. There was no "master plan" prepared in the early nineties to restructure the Finnish economy. It was rather a series of policy measures over a longer period that were working at the same direction. Section 3 takes a closer look at science and technology policies. In section 4 we discuss the structure of the Finnish ICT sector and try to explain the main factors for the rapid resurgence of the economy and the spectacular growth of ICT cluster. Finally, section 5 concludes the theme of "the Finnish miracle". It also discusses the possible lessons to be learned. Our main conclusion is that the Finnish model cannot be replicated as such. There might be, however, some useful experiences that other, especially smaller countries, could possibly benefit from.

2. Phases of Industrial Development – Role of Science and Technology Policies

From factor-driven to knowledge-driven growth - a historical backdrop

During the twentieth century Finnish GDP per capita grew at an annual rate of close to three percent, i.e., faster than in any other European country. Admittedly, as compared to the countries in the vanguard of the first industrial revolution in the late 1800s, the starting point was relatively low. Many of the basic preconditions for growth were nevertheless in place at that time. Institutions, like well functioning educational and banking system as well as good transportation infrastructure, were important in the take-off phase. Similarly, national identity and culture were strong enough to facilitate economic growth. After completing the liberalisation of both internal and external trade by the end of 1870s, the path for industrial growth and new business activity had opened. The role of institutions was important not only in the take-off phase of industrial growth, but also later when the economy moved from factor-driven to investment-, and later, innovation-driven stage of industrial development.

Finland's most important – and virtually only – endowment of natural resources, forests, proved to be the decisive factor in the take-off phase. Quick advancement in prosperity towards the end of the 1800s and in the early 20th century were based on rapidly growing exports of forest-related products, first sawn timber and later pulp and paper. From the late 1950s to the late 1970s the Finnish forest industry carried out massive investments and transformed itself gradually into a global technology leader with the most modern and efficient production capacity in the world (see Raumolin 1992). By the late 1980s the forest sector had developed into a competitive industrial cluster that today provides high value added paper grades as well as forestry technologies and consulting services (Hernesniemi, *et al.* 1996; Ojainmaa 1994; Rouvinen and Ylä-Anttila 1999).

The latest phase of forest cluster development is the integration of ICTs into pulp and paper making processes and maintenance services. The strong forest cluster with roots in traditional factor-driven industries is finding interfaces with the knowledge-driven ICT cluster. Furthermore, the global consolidation in pulp and paper as well as in other traditional industries has spanned new ICT markets, as new electronic means of integrating geographically dispersed activities are needed.

Small Nordic Economy and Welfare State

Finland's economic and social structure and institutions are similar to those of other Nordic countries. It can be appropriately characterised as a Nordic welfare state: an egalitarian country with relatively even income distribution, low class distinctions, and relatively high social cohesion.

Smallness is both an advantage and a disadvantage. There is some evidence in the economic literature that smallness as such might retard economic growth.[3] Small countries have less scope for utilising scale economies in production and marketing. On the other hand, small home markets drive firms to specialise and seek foreign markets early on. Most small countries can be described as open economies with large exporting sector and high ratio of FDI to GDP. In Finland exports in relation to GDP is currently close to fifty percent.

Smallness and homogeneity of the society might also be beneficial for creation and diffusion of new knowledge in specific areas – like ICT. In the period of rapid technical change this could be a competitive advantage over larger countries (cf. Lundvall 1998).

Smallness and specialisation increase a country's sensitivity to external shocks. Small economies have developed various ways to cope with the problem including not only macroeconomic policy measures but also many kinds of formal and informal networks and social security systems. As argued by, e.g., Rodrik (2000), openness of the economy is often linked to social security systems designed to dampen down the risks arising from the high degree of exposure to the external environment.

The Finnish economy can be characterised as highly open, specialised, and networked. Networking and cooperation in society in general, as well as in the business sector and between industry and universities in particular, have proved to be important in developing new information and communication technologies in Finland (Romanainen 2001). Of course, social networks (or social capital more generally), can become too tight and finally an obstacle for social change and industrial transformation, but so far the benefits of networking and cooperation have been an advantage rather than a disadvantage (cf. Castells and Himanen 2002; Rouvinen and Ylä-Anttila 2003).

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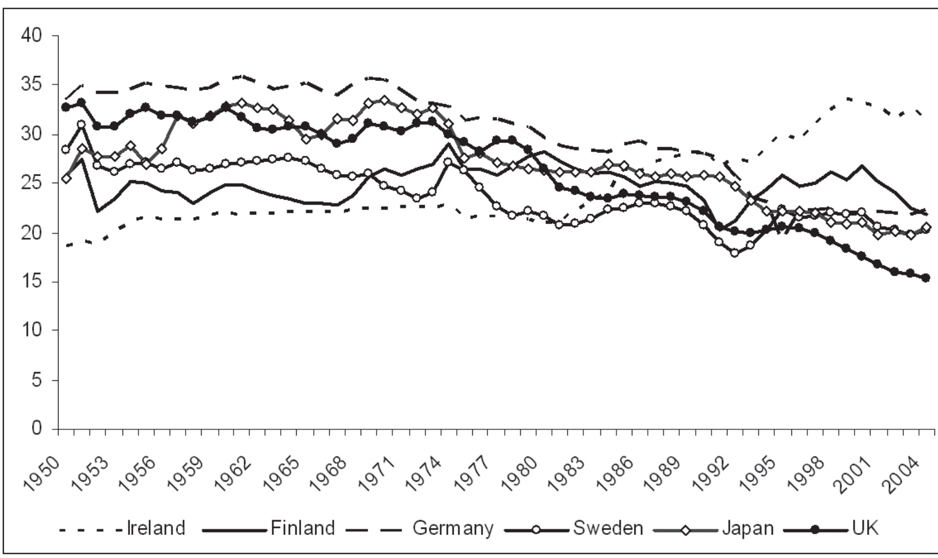
3 – See, for instance, Jones (2002).

Sometimes the risks related to the exposure and smallness might grow too big to be managed properly. This is highlighted by the case of the Finnish economy in the late 1980s and early 1990s when the overheating of the economy ended in a deep recession in 1991–1993. GDP fell by more than ten percent and unemployment rate rose to 17 percent. Such dramatic changes over a very short period of time would probably not happen in a larger highly developed country.

The latter part of the 1980s saw a series of deep structural changes in the Finnish economy. The strong economic growth was strengthened by booming international market, improving terms of trade, and deregulation of the financial market. In spite of the growing international market, exports grew considerably slower than domestic demand. The economy descended into severe structural problems. The export capacity was simply too small to support the late 1980s standard of living.[4] Manufacturing and exports in relation to total output had dropped dramatically throughout the 1980s (Figure 1) leading to a huge external imbalance. Overheating of the economy and the subsequent recession of the early 1990s was partly due to external shocks and partly due to badly designed deregulation of the financial markets.

Figure 1. Share of manufacturing in GDP in selected countries, %



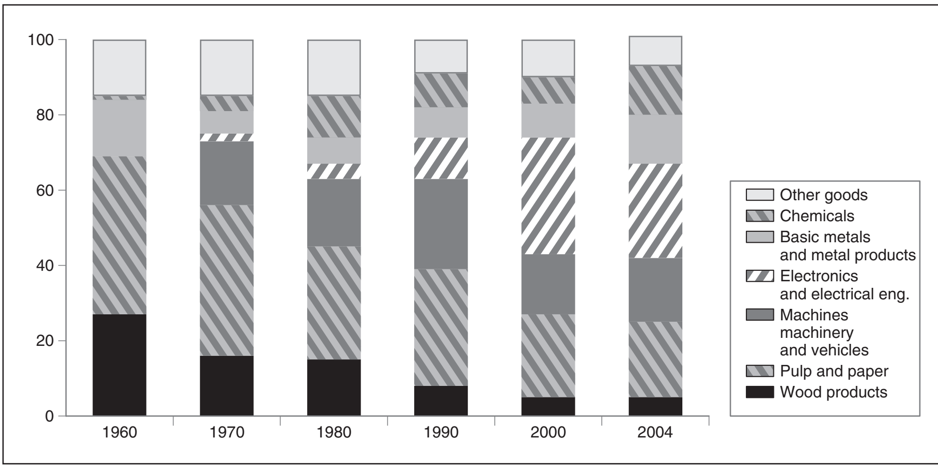
Note: The data source is OECD National Accounts.

Nevertheless, the recovery from the recession was very strong and entailed an era of both re-industrialisation and rapid structural change towards a knowledge-driven economy. In 1990 wood, pulp and paper accounted for 40% of Finnish exports, slightly above the share of metal and machinery products approaching one third. During the 1990s Finland became a major exporter of electronics and other high-tech products, which by the year 2000 accounted for over 30% of exports (Figure 2) The structural change in production, exports and R&D were, indeed, very strong in international comparison. Only some newly industrialised countries have shown similar patterns of rapid structural transformation.[5]

4 – See Hernesniemi et al. (1996).
5 – See Knell (2003).

At the same time when manufacturing was performing well, many service industries increased their output and employment only relatively slowly. Unlike in other OECD countries, manufacturing increased its share in GDP in the 1990s, while the share of services remained more or less constant. Consequently, the share of the services sector in total employment and production in Finland is still well below the OECD average.

Figure 2. Share of exports by industry sector in Finland, 1990 – 2002, % of total exports of goods



Source: National Board of Customs.

3. Science and Technology Policy – How did it Develop?

Why is science and technology policy needed?

High and sustained growth is among the most important goals of practically all policy makers. There is no doubt that new knowledge, innovation and technical change are the most important factors in economic growth and competitiveness. Hence the policy issue is to foster technological advance and harness it to producing product and process innovations that are competitive on the global market. There is growing amount of evidence, although mixed, that public R&D policies can have a positive contribution to overall R&D input and productivity.[6]

Technology policy is usually coupled to market failure, i.e. market will fail to provide sufficient resources to R&D. Social return to R&D exceeds the private return, since R&D has characteristics of a public good. There are basically two types of market failures which policies aim to rectify. First, imperfections in the financial market (often due to informational asymmetries), and secondly market failures arising from knowledge spillovers.

6 – David et al. (2000) provide a review of R&D subsidy studies. For the most recent studies on R&D subsidies' impacts, see Guellec and Pottelsberghe de la Potterie (2003), who use country level data from 17 OECD countries. Their most interesting result is that direct government funding of R&D performed by firms has a positive effect on business financed R&D. The subsidy elasticity of private R&D is of the order 0.07. Ali-Yrkkö and Pajarinen (2003) use firm-level data on Finnish metal, engineering and electronics firms. They receive similar results. Public R&D funding increases private R&D input.

Innovation outcomes are highly uncertain and the innovation process is inherently complex by nature. Innovation policy aims to manage the uncertainty and remedy deficits in firms or the environment in which they operate.

There are basically two types of uncertainties in the innovation process – inside the firm itself, and in the relations between the firm and its external environment. Regarding the external relations the key finding is that firms very seldom innovate alone. Rather, they draw on knowledge generated within the education system, research institutes, other firms or elsewhere in the innovation system. Hence, there are knowledge spillovers both between firms and between firms and other agencies. Thus, the influence of external economies, is the main justification for government involvement in many countries today.

It is evident that characteristics of innovation system affect innovation performance. The evidence seems to suggest that the public support apparatus cannot consist of a single set of activities. In a similar way as innovation is complex process, the support system is characterised by complexity: there are different organisations with different functions and objectives that should, however, operate in a coordinated way.[7]

A closer look at the S&T policy in Finland would reveal a gradual change in policy thinking towards the more complex notion of innovation and a broader view of policies. Since the 1980s there has been a move from linear innovation model to an interactive and integrative model. In 1990 the concept of national innovation system was introduced in the review of Science and Technology Policy Council as a basic framework for policy considerations. The important point is, however, that the principle of innovation system approach has been very pragmatic and at a fairly general level of formulation.[8] The same applies to industrial clusters and cluster-based policies – adopted in industrial policy making in the early 1990s – although the policy reasoning relied heavily on the arguments provided by research.[9]

Basic features of Finnish S&T policies

The evolution of the Finnish science and technology policies can be divided into three major phases: (1) Building the basic structures (1960s and 1970s), (2) technology orientation phase (1980s), and (3) the era of building the knowledge-based society and national innovation system (1990s).[10] The shifts in policy design reflect the changes in industrial and technological specialisation and reactions to changing policy priorities in other OECD countries.

In the mid 1970s Finland started to move from factor-driven to more technology-driven industrial growth. That coincided with increasing public R&D inputs, enhancing integration of science, technology and industry, and, finally, strengthening of technology policy organisations.

By the end of the 1990s technology policy had reached most of the targets that were set in the 1970s and 1980s: more versatile industrial and export structure, lower dependence on raw material and energy-intensive industries, and a growing importance of high-skilled

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7 – See Georghiou et al. (2003).
8 – See Ormala (2001) for a detailed description of policy organisations and practices.
9 – See Jääskeläinen (2001) who makes a strong argument that the research program on industrial clusters carried out in 1991-95 had a major impact on policy making. The results of the cluster studies are summarised in Hernesniemi et al. (1996) and in Rouvinen and Ylä-Anttila (1999).
10 – See Lemola (2002).

and high-tech industries. The economy as a whole entered a phase of innovation-driven growth. Today, the major policy challenge for Finland is to keep the position as one of the leading knowledge-based economies, and to foresee the changes that will reshape the policy environment, i.e. to pursue proactive policies.

Phases of development[11]

The building phase of the 1960s and 1970s

The institutionalisation of science and technology policy began in Finland in the early 1960s, and five important changes took place over the two decades.

1) The policy doctrines (conceptual fundamentals of science and technology policy) were created.

2) A ministerial committee on science, the Science Policy Council (from 1987 the Science and Technology Policy Council), was established in 1963 for the formulation and coordination of science and technology policy guidelines.

3) New mechanisms for planning, coordination, and financing of university research were created, including the Academy of Finland and universities,

4) Measures to improve the conditions for industrial R&D were implemented. These included the strengthening of VTT's (Technical Research Centre of Finland) activities for applied technical research and for research- and piloting services offered to the industry, financing of target research activities in nationally important technology development areas, and the direct support of firms' R&D by R&D loans and grants (MTI - Ministry of Trade and Industry, Sitra - National Fund for Research and Development). The Foundation for Finnish Inventions was set up in 1971.

5) The development of higher education in general played a significant role in the early years of science and technology policy.

The technology phase 1980s

A key aspect in the beginning of the 1980s was to make technology policy increasingly target-orientated and systematic. To fulfil these tasks, Tekes (The National Technology Agency) was set up and some of the tasks of MTI (R&D loans and grants as well as appropriations to technical target research) were transferred to Tekes. National technology programs became a new and important instrument for implementing technology policies. The focus of Tekes' operations in the 1980s was on information technology. In fact two technology programs in information technology had already been initiated before the setting up of Tekes, in which Nokia had also played a large role. Towards the end of the 1980s the need for policy actions on a broad sectoral basis was recognised, and the development of technology programs towards traditional industries was started.

11 – Lemola (2002). See also Ormala (2001), which gives an extensive review of institutions and policy agencies as well the developments in the 1980s and 1990s. See Georghiou et al. (2003) for an evaluation of innovation support system. Ylä-Anttila and Palmberg (2005) is an extensive description of the specificities of Finnish industrial policies.

Another trend in the 1980s was technology transfer and the commercialisation of research results. A number of mechanisms for technology transfer, diffusion and commercialisation, such as nation-wide networks of science parks and centres of expertise, were created.

Economic growth in Finland in the 1980s was also faster than in most other industrialised countries. An important change in the industry was the diversification of the export industry and internationalisation. A key player in promoting exports and internationalisation was the Finnish Foreign Trade Association (later Finpro). The ratio of R&D expenditures to GDP in Finland had been one of the lowest in the OECD countries at the end of the 1970s. The real growth rate of R&D expenditures in the 1980s was about 10 percent annually, which was the highest in the OECD countries. This was largely due to increasing R&D spending by companies.

Era of the national innovation system

A new ideology initiated by the Science and Technology Council began to form at the turn of the 1990s, embracing the "national innovation system" and "knowledge and know-how" as central elements. This emphasised four viewpoints: creation and utilisation of knowledge and know-how, the R&D system at the core with education having an important role, the influence of the general atmosphere and environment on the development and take-up of new technologies, and the ability to cooperate both nationally and internationally. The concrete target was to increase R&D expenditures.

Finland was the first country to adopt the concept of a national innovation system as a basic element of science and technology policy.[12] That reflected the idea of looking at the innovation process and policies from a broad perspective spanning from education and science to innovative activities of firms and commercialisation of technological innovations. Cluster-based industrial policies also fit well in this line of policy thinking.

Towards the end of the 1990s, commercialisation of the results of R&D seems to have received increasing emphasis again. This applies to internationalisation too. The Finnish Foreign Trade Association (today Finpro) was reorganised in the late 1990s, and in part inspired by that, it began to look for stronger position as part of the innovation system.

A specificity of the "Finnish innovation model" has been the early adoption of systems view in industrial and innovation policies. This view could be described as an acknowledgement of the importance of interdependencies among research organizations, universities, firms, and industries due to increasing importance of knowledge as a competitive asset. The systemic approach to policymaking is based on the notion that various stages of innovation process often are simultaneous rather than sequential, and funding and services are demanded accordingly.[13]

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12 – Miettinen (2002).

13 – See Dahlman, Routti and Ylä-Anttila (2006) in more detail.

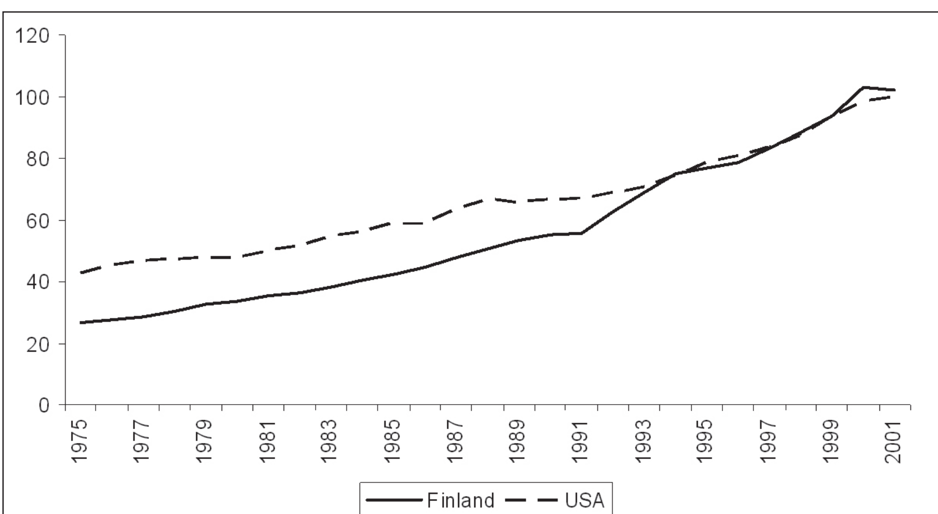
4. The 1990s – Towards a Knowledge-Based Economy

The 1990s was then both an era of re-industrialisation and rapid structural change towards a knowledge-driven economy. However, the foundations of the Finnish transition to a knowledge-driven economy were laid in the course of several decades. The key factors were raising investment in R&D and commitment to education. In a few decades Finland went from being one of the least R&D-intensive OECD countries to being the second most R&D-intensive today. Even in the midst of the deep recession of the early 1990s overall R&D investment remained high and public R&D support even rose at the time when virtually all other public expenditures were cut.

The export-led recovery from the recession brought about not only a major industrial restructuring, but also a subsequent improvement in productivity performance of the manufacturing sector. Today manufacturing productivity is above the US level, while that of the total business sector is well below.

The rise in manufacturing productivity was mainly due to "creative destruction", i.e., to major changes in production, firm and industry structures. Strong plant-level restructuring cleaned low productivity and low technology plants, and new plants representing high technology and high productivity industries came in their place.[14] Hence, aggregate productivity increased, although productivity at plant and firm level did not change much. The flip side of the high productivity performance is stubbornly high unemployment. Numerous jobs have been destroyed in low productivity and often low technology plants, while practically less new jobs have been created in high-tech industries and plants. Maliranta (2002) shows that the productivity contributions of R&D, too, came through micro-level restructuring, i.e., plant-level restructuring was needed to reap the benefits of technological advance.

Figure 3. Labour productivity in manufacturing: Finland and the United States (US 2001 = 100)



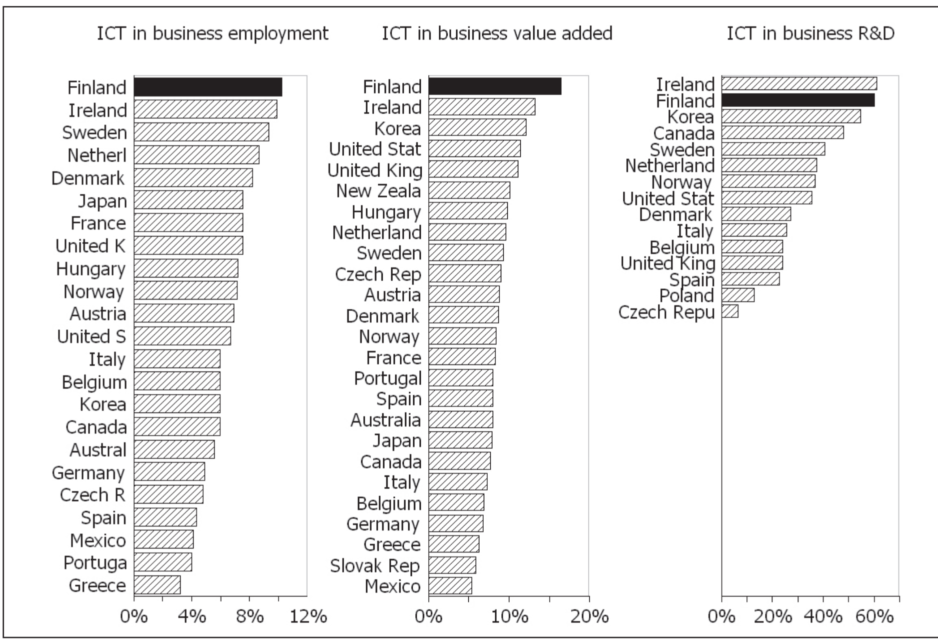
Source: Koski et al. 2002.

14 – Maliranta (2002).

Although the restructuring of the 1990s was wide-ranging and covered practically all sectors in the economy, its was very much driven by the ICT sector, and by mobile telecommunications in particular. In the beginning of the 1990s Finland was one of least ICT specialised countries, today the most specialised. Such leapfrogging is rare, and very unlikely in an historical perspective in general.[15]

Jalava and Pohjola (2001) show that macroeconomic effects of ICT in the late 1990s were quite similar in Finland and in the United States. As distinct from the situation of the United States, however, the effects in Finland are mostly mediated via ICT *provision*. ICT penetration rates are nevertheless quite high and the country is a leader in certain types of ICT usage, e.g., online banking and mobile payments. Although in most respects Finland is also an advanced user of ICT, it nevertheless seems that as a *user* it is not as exceptional as it is as a *producer*. This is somewhat alarming, as the long-run economic effects of ICT are mostly mediated via its use[16].

Figure 4. ICT specialisation, selected countries



Source: OECD.

A specific feature of the Finnish ICT driven economy is the dominant role of one company, Nokia. Nokia accounts as much as some 80% of total exports ICT goods and services and more than that of ICT-related R&D. Nokia's share in the country's exports is one fifth, and share of industrial research and development about 60%. Hence the story of ICT-led growth of the 1990s is very much that of Nokia.

As discussed by Palmberg (2001), despite Finland's extraordinary and almost unique success in transforming its industrial structure towards high-tech industries, it is important

15 – See Koski, Rouvinen and Ylä-Anttila (2002).
16 – See also Rouvinen and Ylä-Anttila (2003).

to notice that a significant part of the Finnish economy continues to rest on manufacturing or service activities that are 'traditional' (in the sense that they are a long-standing part of the system). Finland continues to have an export specialisation in pulp and paper and timber products, for example. Industries such as pulp and paper are often regarded as low technology, since their own R&D input in relation value added is low. Nevertheless, pulp and paper and timber industries are typical examples of sectors that are major users of knowledge generated elsewhere. These kinds of industries constitute an important part of the knowledge system where the flow of knowledge across industries and organisations leads to technological upgrading and increases innovation potential.[17] The big issue today is, how the front runner position in production of ICT can be transformed into efficient use of these technologies in traditional manufacturing industries and, especially, in services.

The 1990s was an important period, since it speeded up the process of structural change that had started already some 10 – 15 years earlier. Rapid structural transformation also enhanced the system thinking among policy makers – there was a need to get a comprehensive picture of the restructuring and its possible outcomes.

5. Conclusions

How do we explain the 'Finnish miracle'?

The performance of the Finnish economy in the 1990s was remarkable. It looked as though the economy had found a unique way to combine high social security, dynamism, and growth. Successful policies contributing to the Finnish success story were equated with a new economic model for the information society or knowledge-based economy.

While in hindsight the Finnish public policies of the 1990s were successful, the 'Finnish miracle' can only be partially explained by public policies pursued in the 1990s. The necessary policy changes had already been made in the 1980s, with some having come as early as the 1970s. Building competitive advantages takes time. There was no 'master plan' to restructure the Finnish economy and industry in the 1990s; rather an array of policy measures were working to the same end over an extended period of time.[18]

However, policies pursued since the early 1990s have had their role as well. There was a major shift in priorities as a consequence of European integration and changes in comparative advantages of the economy; focus shifted from short-term macroeconomic to long-term microeconomic policies. It is nevertheless true that sound but stringent macroeconomic policies contributed to the recovery. While joining the EU and EMU narrowed the scope of macroeconomic policies, it also brought new stability with moderate inflation, low real interest rates, and increasing predictability of fiscal policies.

Under these circumstances, the increased emphasis on microeconomic and especially innovation policies has been a successful choice. These new policies are based on indirect measures aimed at influencing firm behaviour. Policies concentrate on rectifying market failures, promoting competition, and improving framework conditions. These types of 'enabling policies' fit well into the economic environment of the 21st century. The key priorities today are innovation policies and policies for enhancing the functioning of capital markets.

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17 – Palmberg (2003).
18 – See Georghiou et al. (2003).

Although the ‘high-road’ strategy of innovation and technology has been emphasised only recently, it was initiated in the 1970s and 1980s. In the 1980s, long before the rise and fall of the ‘new economy’, Finnish technology policy began to give high priority to ICT. These policies were continued in the following decade and they undoubtedly contributed to the success story of the 1990s. Finnish R&D investment increased continually and networking between public and private actors was enhanced.

Finland was lagging behind the rest of Europe in industrial development after World War II. It consciously upgraded its skills and competencies and in half a century caught up with the leaders. Leapfrogging in the 1990s nevertheless involves many coincidental factors and good timing. Thus, Finland has been fortunate, but the fact that it was well-positioned when the opportunity provided by ICT revolution arose, had nothing to do with luck. Historically Finland has been a catching-up economy; now it is one of the leaders that is a much more demanding position.

Crises and creative destruction

It has been pointed out by several scholars that small countries need and are often able to combine openness to the external world with internal cohesion.[19] That seems to have been true in Finland in the 1990s. Small countries usually experience more volatile growth and are sensitive to external shocks. Sometimes these lead to crises that cannot be managed by ordinary macro policies. That is what happened in Finland in the early 1990s. The country was hit by a deep recession that was followed by very rapid export-led growth and profound structural change. The economy opened further to the external world by lifting the remaining capital constrains and restrictions of foreign ownership. Finland was also in the forefront in liberalising the telecom market that started in the 1980s and continued to full liberalisation by the mid-1990s.

The economy took advantage of the booming global ICT market and increasing capital flows. There was an influx of capital to the country that facilitated the expansion of ICT firms. The economy that was among the least ICT specialised among the OECD countries became one of the most specialised just in less than a decade. This would probably not have been possible without the internal cohesion and acceptance of economic and social changes that were motivated by the crisis.

The price of the spectacular growth and productivity performance has been a fairly high unemployment. During the post recession period jobs have increased predominantly in the high-tech industries and high productivity plants. Hence, attaining the top position in manufacturing productivity has mainly been a process of creative destruction. From now on productivity advances have to come from intelligent applications of ICT, i.e. more from use than production of ICT goods and services.

The crisis touched not only the national economy and its financial sector, but also the biggest corporation in the country. In the beginning on the 1990s Nokia was still a diversified multi branch company in deep financial crisis. In a couple of years it divested most of other industries and focused heavily on telecommunication equipments. By the end of the nineties it was one of the most profitable companies and the biggest producer of mobile phones worldwide. Interestingly, the country experienced three major turning points at the same time and at different levels: global ICT revolution, national financial and economic crisis, and deep restructuring of the biggest industrial corporation. The key issue in the Finnish success story is adjustment and ability to turn these crises into opportunities and growth.

19 – See Bräutigam and Woolcock (2001), and Lundvall (1998).

Lessons to be learned?

It is hard to say if there are any lessons for other countries to be learned. Economic and social models come and go.[20] It was no later than the end of the 1980s when the Japanese economic and social model was celebrated as an ideal to the rest of the world. Today, it serves an example of an economy that has failed to make the necessary reforms and where more flexible economic and social structures are needed.

However, it might be an advantage of small countries to adjust more flexibly and create institutions more conducive to change. The Finnish experience suggests, at least, that a deep crisis often precedes considerable and lasting shifts in economic and social structures. It looks that small countries with greater homogeneity and closer interaction (networking) among economic agents may well be better equipped to cope with deep structural changes. They may also have an advantage in adjusting to new technologies and, hence, in generating long term economic growth.

The Finnish experience indicates that institutions matter. High quality institutions and social innovations matter in terms of managing exposure to global economy. Openness to the external world has to be combined with dense interaction and networking internally.

One indisputable lesson from the Finnish experience is that innovation policy must have a long-term strategic perspective. Hence, policies must be consistent over the long-term and not dictated by short-term cyclical or political considerations.

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VII. INDUSTRIAL AND TRADE DYNAMICS IN THE BALTIC SEA REGION SINCE 1990'S

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1. Introduction

The aim of this chapter is to review the dynamics of economic development in the Baltic Sea region assessing the quality of economic change and prospects for future development.[2]

We believe that economic development is path-dependent and therefore, to understand properly the observed developments, one should study carefully both the macro-economic trends and the evolution of the specialisation patterns as characterised by the changes in the structure of industry and trade – the emergence of new higher value added industries at the expense of the gradual decline of mature industries. Longer-term economic development is rarely smooth and sustained. The ever increasing competition stemming from the globalisation of trade, capital markets and technology leaves policy-makers therefore with a complex task of handling the Schumpeterian *creative destruction* (Schumpeter 1939).

In the following chapter, we take the beginning of the 1990s as the starting point of our review, as it appeared to be an important turning point in time for many of the countries in the region, which denoted in many ways an end of an era and

1 – The author would like to express the gratitude to Juhan Jüriado and Julia Wörz from INDEUNIS project for exellent research assistance and invaluablesupport in data collection. Feedback provided by Janusz Chojna, PeterHavlik, Rainer Kattel and others on the earlier versions of this article is most gratefully acknowledged.
2 – The Baltic Sea region is defined for the purposes of this paper as the group of the following countries located around the Baltic Sea: Germany, Denmark, Sweden, Finland, Estonia, Latvia, Lithuania, Poland, and Russia. When discussing intra-regional interdependencies, some of the larger countries may be still occasionally neglected giving closer attention to a number of "core countries" which are the most dependent on the developments in the region.

Abstract

The chapter reviews the dynamics of economic development in the Baltic Sea region since the early 1990s. It can be noticed that both the public policy responses to the albeit seemingly somewhat diverse economic crises and their outcomes varied significantly. While the Nordic countries employed rather proactive approaches for upgrading their existing competitive assets, the Baltic States, Poland and Russia focused predominantly on the stabilisation of the macroeconomic framework, paying relatively little attention to the actual capability of the industry to cope with rapid changes. As could be easily expected from a common-sense point of view, the above developments led to a strengthening of the industry in the Nordic countries and to the demolition of a large part of inherited, although largely uncompetitive, industries in the Baltic States as in the majority of the rest of the former Soviet block.

a start of a new one. It was the time that brought about the reunification of Germany and the collapse of the Soviet Union (USSR), but it was also a point in time when several Nordic countries suffered from a severe economic crisis which was followed by a miraculously rapid recovery. In contrast, the crisis in the former USSR endured longer and was also much deeper. The Baltic States were the first to manage to stabilise their economies, yet at the cost of the loss of previously overwhelmingly dominant Eastern markets and a large part of the inherited industrial assets. The growth resumed in Russia only after the 1998 crisis.

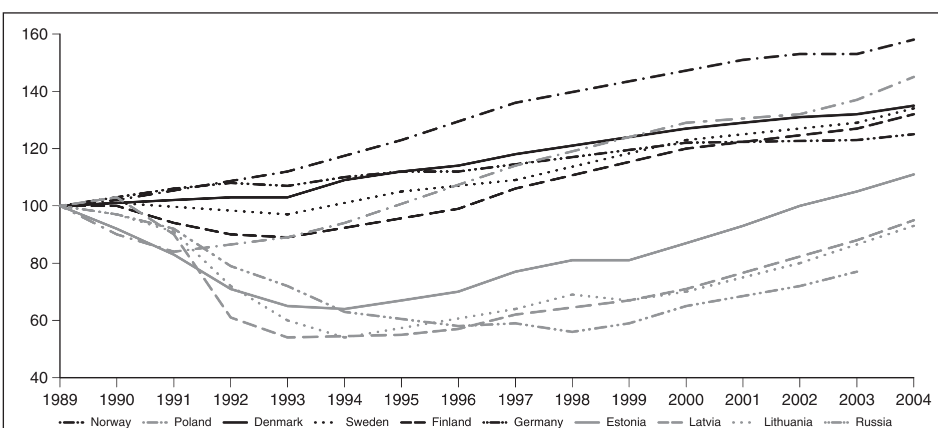
2. Economic Crisis in the Early 1990s and Rapid Recovery Thereafter

The 1980s and 1990s brought about a period of much more frequent and severe financial and economic crises in the developing world, e.g. in Latin America, and elsewhere than witnessed in earlier decades. Despite the above, even in the mid-1980s, very few people would have foreseen that, in 1991 the Soviet Union dissolved.

The loss of the Eastern markets and the collapse of loan and real estate booms led Finland in 1991-1992 to the most severe economic crisis experienced in the OECD countries since WWII. The Finnish economy recovered exceptionally rapidly, and Finland became by the end of the decade one of the most competitive economies in the world. In the early 1990s, more or less at the same time with Finland, also Sweden experienced a financial crisis which led her economy into recession for a few years.[3]

Yet, the crisis in Finland or Sweden was fairly mild, as compared to the post-Soviet transitional crisis experienced in Central and Eastern Europe and the former Soviet Union. Inasmuch as one can trust the estimates of the GDP of the Soviet Union of the 1980s, the three Baltic States suffered during the early 1990s from rather severe 'transitional recession' with cumulative output declines in the region of 40-50%. (Figure 1)

Figure 1. Real gross domestic product 1989-2004, index 1989=100



Source: Groningen Growth and Development Centre 2005

3 – In Finland, the real GDP dropped in three years by over 10 percent, and unemployment rose by 1994 to nearly 17 percent, starting then slowly to decline. See Honkapohja and Koskela (1999), Kokko and Suzuki (2002).

Estonia was the first of the Baltic States to escape the hyperinflation caused by the collapse of the USSR by introducing in 1992, as part of the economic stabilisation programme, its own currency, escaping thereby the hyperinflationary *ruble zone* and setting a stable macroeconomic environment for the growth to follow. Latvia introduced its own currency in 1993, Lithuania followed in 1994.

The growth resumed around 1995 and the real GDP growth has been quite remarkable since then. Since 1995, the GDP growth (in constant prices) has been much faster in most of the countries in the Baltic Sea region (with the exception of Germany) than the growth in EU-15 on average. The emerging economies in Eastern Europe, East Asia, etc. have continued to grow at a relatively good pace even from the year 2000 onwards, when the growth slowed down in the majority of the developed countries. The recent growth in the Baltic Sea region has been faster than in the United States, and in 2004, the Baltic States were the fastest growing economies in the enlarged European Union.

In the following sections, we shall review the dynamics behind the recent remarkable growth in the region and different policy responses to the crises in the early 1990s in individual countries.

3. Trade Dynamics and Changes in International Specialisation

3.1. Export Growth and Trade Linkages

The volume and pattern of trade have changed tremendously in the region during the past one and a half decades. Until 1991, the Baltic States were completely integrated into the economy of the Soviet Union. In the command economy environment, approximately 70% of its trade turnover went to the East. As described above, the collapse of the Soviet Union and the related economic crisis brought a rapid drop of output and the collapse of the industrial sector. The number of larger manufacturing companies decreased sharply and in each of the Baltic States only 2-3 major industrial companies survived the transition.

Although the Soviet Union was in 1990 also for Poland the most important trade partner, the economic ties were incomparably weaker between these two countries: only 15% of the Polish imports came from, and 21% of the exports went to the Soviet Union. A few years later, in 1994, the trade with Russia accounted only for a minor share of the Polish trade, while Germany had became the main trade partner of Poland, accounting for about 1/3 of the Polish foreign trade portfolio, which was otherwise widely diversified (United Nations 2005).

For Scandinavia, the trade with the Soviet Union was only of inferior importance in 1990. While for Finland, which had the closest ties with the USSR among the Nordic countries, the eastern market was one of the four main export outlets besides Sweden, the Federal Republic of Germany and the United Kingdom, each accounting for 10-15% of the total of Finnish exports. For Sweden, Denmark and Germany, the USSR was not even among the top five trade partners. Equally, the above countries accounted for less than 20% of the foreign trade of the Soviet Union.

Sweden and Finland recovered from the financial crises fairly rapidly and have shown since then quite fast growth of GDP and exports. Germany witnessed drawbacks related to the unification with the former GDR, but has recorded steady growth since then. Denmark remained all together intact from external shocks in the early 1990s.

Similarly, also Poland overcame the transitional crisis fairly rapidly. The growth in the Baltic States picked up again slightly later. However, the average annual growth of the foreign trade of the Baltic States and Poland between 1995 and 2004 was two to three times faster than the growth of exports of the rest of the countries in the region. (Eurostat 2005a).

While the exports of the Baltic States' trade were until the collapse of the Soviet Union virtually completely oriented to the eastern markets, drastic changes have taken place in their trade orientation over the last decade. The Baltic Sea region has become a closely integrated cross-border economic region, where intra-regional trade constitutes an important part of the trade of the individual countries (Table 1).

Table 1. Share of the intra-regional trade for individual countries, 2004.

Import:

	DK	EE	FI	DE	LV	LT	PL	SE	RU	BSR9
Denmark	:	0.3%	2.1%	21.4%	0.3%	0.5%	1.8%	13.3%	1.0%	**40.7%**
Estonia	2.4%	:	20.0%	12.4%	4.1%	5.1%	3.2%	9.4%	9.4%	**66.1%**
Finland	5.2%	2.5%	:	16.2%	0.2%	0.1%	0.9%	14.3%	12.8%	**52.3%**
Germany	1.7%	0.1%	1.0%	:	0.1%	0.1%	2.7%	1.8%	2.7%	**10.2%**
Latvia	3.0%	7.0%	6.4%	14.0%	:	12.3%	5.5%	6.2%	8.8%	**63.2%**
Lithuania	3.6%	3.3%	3.4%	16.9%	3.9%	:	7.7%	3.4%	23.2%	**65.4%**
Poland	1.7%	0.1%	1.4%	28.2%	0.3%	0.6%	:	2.8%	7.1%	**42.2%**
Sweden	8.8%	0.8%	6.1%	18.2%	0.4%	0.5%	2.4%	:	2.4%	**39.7%**

Export:

	DK	EE	FI	DE	LV	LT	PL	SE	RU	BSR9
Denmark	:	0.2%	2.9%	18.3%	0.3%	0.4%	1.5%	12.8%	1.3%	**37.7%**
Estonia	3.3%	:	22.9%	8.3%	8.0%	4.4%	1.0%	15.2%	5.6%	**68.7%**
Finland	2.2%	2.8%	:	10.7%	0.7%	0.5%	1.7%	11.1%	8.9%	**38.6%**
Germany	1.5%	0.1%	1.0%	:	0.1%	0.2%	2.6%	2.2%	2.0%	**9.7%**
Latvia	5.4%	8.0%	2.5%	12.1%	:	9.2%	3.6%	10.1%	6.4%	**57.4%**
Lithuania	4.8%	5.0%	0.9%	10.3%	10.2%	:	4.8%	5.1%	9.3%	**50.4%**
Poland	2.2%	0.4%	0.8%	29.9%	0.6%	1.7%	:	3.5%	3.9%	**42.9%**
Sweden	6.4%	0.6%	5.5%	10.0%	0.3%	0.3%	1.7%	:	1.5%	**26.3%**

Source: Eurostat 2005b.

However, the trade balances of the Baltic States, and to a lesser extent also of Poland, are despite the generally favourable developments even 15 years after the start of transition still strongly in deficit (See UNIDO 2005).

A closer look at the relative trade balance of individual countries reveals radically different trade specialisation patterns along the North-Western and South-Eastern coastlines of the Baltic Sea. While the Nordic countries and Germany specialise predominantly in exports of manufactured goods, the Baltic States and Poland record positive relative trade balances mainly in agricultural products and/or raw materials. (Table 2)

Table 2. Relative trade balance, 1999-2004[4]

	SITC	Denmark		Germany		Finland		Sweden		Estonia		Latvia		Lithuania		Poland	
		1999	2004	1999	2004	1999	2004	1999	2004	1999	2004	1999	2004	1999	2004	1999	2004
Food, drinks and tobacco	0&1	0.32	0.28	-0.21	-0.11	-0.43	-0.42	-0.37	-0.31	-0.35	-0.24	-0.52	-0.36	-0.21	0.04	-0.09	0.14
Raw materials	2&4	0.06	0.10	-0.33	-0.28	0.16	-0.04	0.37	0.30	0.43	0.26	0.66	0.49	-0.05	0.02	-0.29	-0.26
Mineral fuels, lubricants and related materials	3	0.06	0.26	-0.67	-0.59	-0.45	-0.41	-0.35	-0.33	-0.62	-0.38	-0.71	-0.62	-0.25	0.01	-0.41	-0.34
Chemicals and related products, n.e.s.	5	0.08	0.14	0.19	0.20	-0.14	-0.33	0.05	0.12	-0.52	-0.43	-0.57	-0.54	-0.33	-0.30	-0.59	-0.44
Machinery and transport equipment	7	-0.08	-0.07	0.21	0.26	0.13	0.12	0.16	0.15	-0.34	-0.27	-0.77	-0.67	-0.47	-0.32	-0.36	-0.09
Other manufactured products	6&8	-0.03	-0.03	0.00	0.09	0.39	0.33	0.13	0.13	-0.04	-0.05	-0.08	-0.10	-0.11	-0.08	-0.04	0.05
Total of all products		**0.05**	**0.06**	**0.07**	**0.12**	**0.14**	**0.09**	**0.11**	**0.10**	**-0.18**	**-0.17**	**-0.26**	**-0.28**	**-0.26**	**-0.14**	**-0.25**	**-0.09**

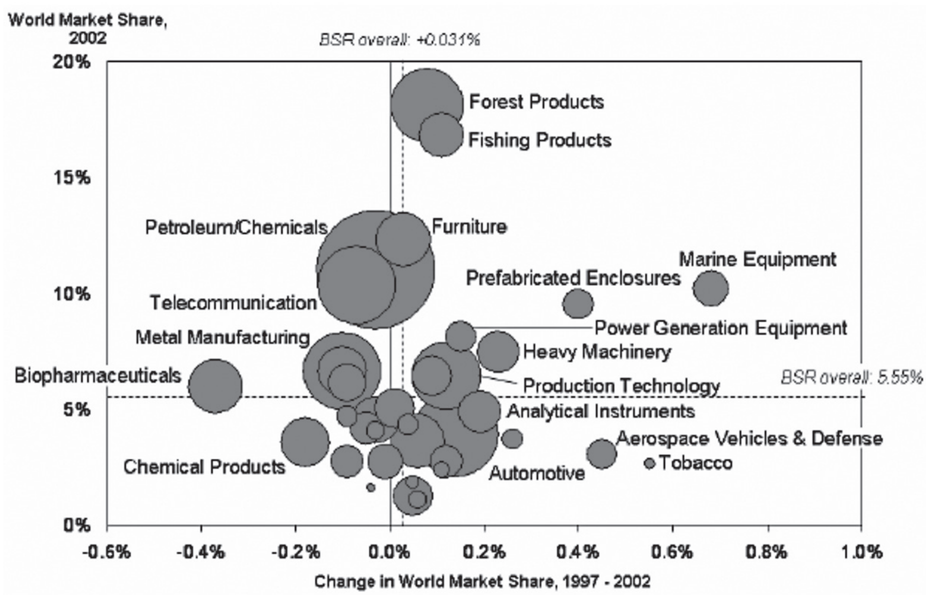
Source: Eurostat 2005a; author's calculations.

4 – The relative trade balance (RTB) for a product i is defined as follows: RTBi = (Xi – Mi) / (Xi + Mi), where X = value of exports and M = value of imports.

3.2. International Trade Specialisation of the Baltic Sea Region

The main export articles of the Baltic Sea region consist of petrochemicals, telecommunication equipment, automotive and transport equipment, metal manufacturing, forest products, and various production technologies, etc.[5] (Figure 2)

Figure 2. World market share of the Baltic Sea region[6]



Source: Ketels and Sölvell 2005, 43.

Sweden is the largest exporter in the region. Its export specialisation, relative to the region's average, consists predominantly of aerospace engines, biopharmaceuticals, automotive, and forest products. Finland is strong in forest products, telecommunication and marine equipment. The Danish strengths are in food products, biopharmaceuticals, power generation (wind energy) and footwear. The German main strengths lie in automotive, aerospace and information and communication technologies. Poland specialises in the manufacture of transport equipment and parts thereof (diesel engines), wood and furniture; also coal is an important export article (Ketels and Sölvell 2005, 44; Tiits *et al.* 2006, 79).

Iceland has an advantage in fishing products, and power-intensive activities such as the production of aluminium. Norway is strong in petrochemicals, fishing products and marine equipment.

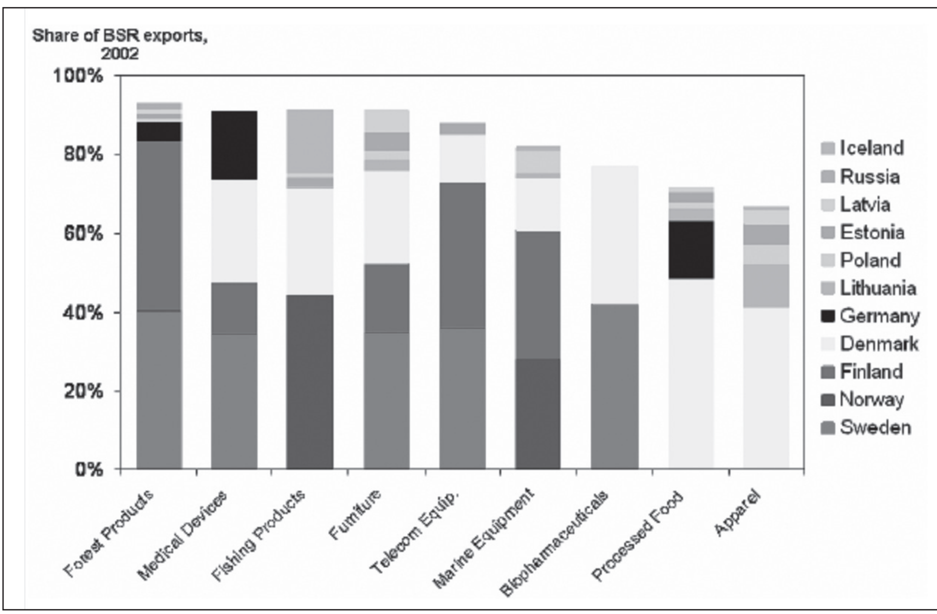
The North-Western region of Russia is one of the most industrially developed among the Russian regions. Its specialisation includes energy production, wood processing, metal

5 – Please note slightly different definition of the region: the data behind this assessment includes also Norway and Iceland.
6 – Note: The above data includes Norway and Iceland.

and machinery manufacturing (energy technology, marine transport equipment), food processing, ICT and electronics manufacturing (Dudarev *et al.* 2002 and 2004). The transit of oil from energy-rich Russia is also an important part of the exports of the Baltic States. The Lithuanian strength besides manufacturing Russian oil lies in transport (railway carriages) and marine equipment. Latvia's strengths are in wood and furniture, food and textiles. Estonia's main manufacturing specialisations are in telecommunication equipment and electronics; wood processing, furniture and printing (*ibid.*; see also *Nordisk Cluster Mapping* 2002).

The similarities in the economic specialisation of the individual (mostly small) countries and the patterns of intra-regional trade alone suggest the existence of close cross-border economic clusters in the Baltic Sea region. In fact, the strong international competitive position of the region is frequently based on a number of the countries which have all revealed a comparative advantage in specific product groups (Figure 3).

Figure 3. Share of cluster exports from countries with RCA > 1



Source: Ketels and Sölvell 2005, 44.

The composition of specific cross-border clusters by individual countries varies from case to case, but as a general pattern, Sweden, Finland, and Denmark hold key co-ordinating positions in such clusters, while the Baltic States and Poland have largely assumed over the last decade the role of a low-end subcontractors.[7]

Given the resource richness of the huge neighbour alone, Russia has always played a special role in the region. In 1990, petroleum, petroleum products, natural and manufactured gas accounted for 62% of the Finnish, Swedish, Danish and German combined imports from the USSR, while the key export articles (20% of all exports) to the Soviet

7 – Evidence from Estonia suggests that the value added of Estonian exports to Finland and Sweden amounts to roughly half of that of the exports to other countries. See Kaasik 2003.

Union consisted of machinery, transport equipment, and articles of pulp and paper (United Nations 2005). While the prolonged crisis in Russia led to the collapse of the light and machinery industries, the trade pattern between Russia and other countries in the Baltic Sea region remained largely unchanged for a decade, except for the increased importance of the exports of electronics to Russia (Bracho and López 2005).

Yet, when assessing the potential for future cross-national co-operation in the region, one should not limit the potential of Russia with its natural resources alone. The North-Western region of Russia is one of the most industrially developed among the Russian regions. It accounts for 9% of Russia's GDP, and almost 10% of its industrial production. The region is also rich in human capital, and it is only a matter of time when the city of St. Petersburg will restore its full glory as the global metropolis. Given the favourable location of the St. Petersburg region, the number of universities and research institutes located there, the region is clearly one of the most attractive in Russia for foreign direct investments.

3.3. Foreign Direct Investments

The Baltic Sea region has been for the last decade in a relatively favourable position in terms of its ability to attract inward foreign direct investments. Somewhat similarly to what happened in the late 1990s in Ireland, also Sweden and Denmark experienced a huge influx of foreign direct investments during the peak time of the ICT investment boom in 1999-2000 (UNCTAD 2006).

In fact, Sweden as one of the main metropoles and business hubs in the Baltic Sea region attracts ½ of all inward investment into the 'smaller Baltic Sea region' (without Germany and Russia), distributing the investments then further to the smaller neighbouring countries, such as Finland, the Baltic States, but also Denmark. The Estonian case is in this context especially remarkable, as the investments originating from other countries in the Baltic Sea region account for 77% of Estonia's inward FDI position. The Swedish investments account for approximately ½ of Estonia's inward FDI position, but there is no data on the entrance of Swedish companies to Estonia via Finnish subsidiaries (Liuhto 2005).

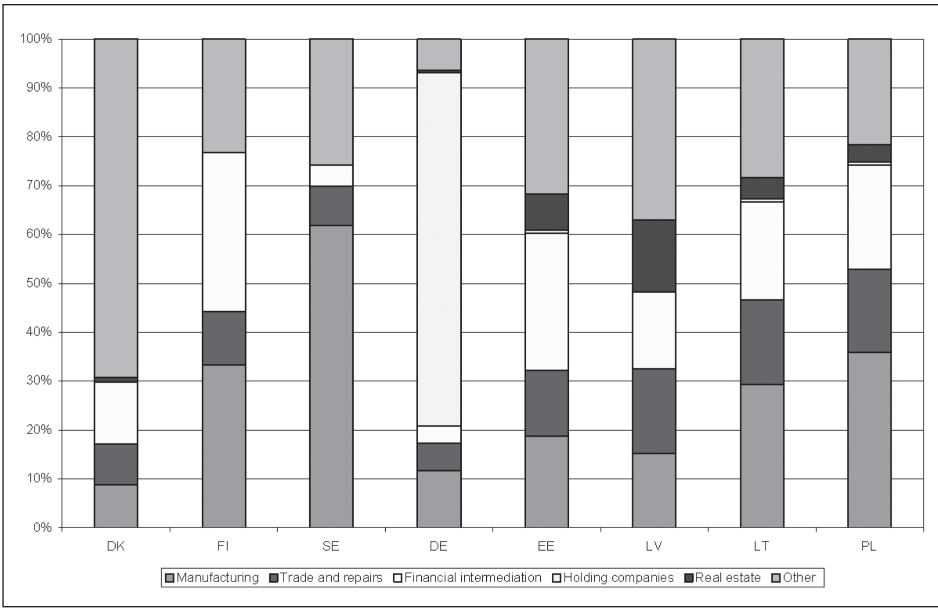
These developments could be attributed in part to the rapid privatisation of formerly state-owned industries, in part to the relative geographic closeness to Sweden and Finland, as investor countries.

While in the early 1990s, participation in privatisation was the main motivation for foreign direct investment to the Baltic States, in the late 1990s, the enlargement of the home market, cheap labour and access to natural resources became a predominant impetus for further investment (Johansen 2000).

The Nordic countries have increasingly seen the Baltic States since the mid-1990s as part of their home market, and the presence of various Scandinavian financial and industrial concerns, wholesale and retail chains, etc. has thereby steadily increased. As a part of this process, Estonia has become the platform for entering the Latvian and Lithuanian as well as the Russian markets for the Scandinavian foreign investment enterprises; hence, a fairly large share of Latvia and Lithuania in the outward FDI position of Estonia. In fact, two-thirds of Estonia's outward FDI position can be attributed to the investments of the financial sector dominated by Scandinavian banking groups in Latvia and Lithuania (Varblane 2001; Tiits 2005; see also Kalotay 2004).

Various service sectors such as financial intermediation, trade and repairs, and others hold the most prominent role in inward direct investments into Estonia and Latvia. The share of inward manufacturing FDI in Lithuania and Poland is very well comparable to the one in Finland. Denmark, Estonia and Latvia still demonstrate extremely low shares and Sweden an extremely high share of manufacturing in their inward FDI position (Figure 4).

Figure 4. Composition of inward FDI position, 2002[8]



Source: Eurostat 2005; author's calculations.

In the manufacturing industry in Estonia, the following fields have received the most foreign direct investments: food and wood processing; and textile and clothing. The same relatively resource-intensive low-tech industries are also prevalent in foreign direct investments made in Latvian and Lithuanian manufacturing industries.

In Poland, besides FDI into the food processing industry, several medium technology industries such as transport equipment and chemicals also appear among the major destinations for direct investment into manufacturing (Table 3).

While the manufacturing share in inward FDI is much higher in Finland and Sweden, chemicals, metal and mechanical product industries are the most prominent direct investment destinations.

8 – Please note that the data are not fully comparable, as no data on foreign direct investments into holding companies were available for Denmark, Finland and Sweden. No data on FDI in real estate were available for Finland and Sweden. The respective investments appear under 'Other'.

Table 3. Inward FDI position in manufacturing industry, 2002

	DK	FI	SE	DE	EE	LV	LT	PL
Food products	41%	26%	4%	3%	21%	25%	38%	22%
Textiles	0%	:	:	1%	9%	12%	11%	1%
Wood, publishing and printing	7%	:	13%	2%	21%	25%	7%	12%
Chemicals and chemical products	10%	12%	42%	23%	8%	9%	5%	12%
Metal and mechanical products	18%	22%	:	12%	5%	14%	3%	8%
Office machinery, RTV, communications	3%	8%	:	17%	4%	0%	4%	3%
Vehicles and transport equipment	1%	:	:	16%	3%	1%	4%	14%
Other manufacturing	19%	33%	40%	27%	29%	14%	28%	27%

Source: Eurostat 2005; author's calculations.

3.4. Productivity, Labour Costs and Employment

The comparison of the wages of industrial workers and the industrial value added reveals that the wages of the industrial workers are considerably higher in the Scandinavian countries and Germany than the wages in East Asian 'tiger economies', such as Singapore or Korea. Yet, the value added per employee and value added share in output tend to be in the above European countries relatively lower than in Asia. This, obviously puts the Europeans in a less favourable competitive position (Reinert and Kattel 2004).

Although the labour costs in the Baltic States and Poland are still less than 1/5 of the Western European levels, productivity tends to be equally low. Furthermore, the labour costs have more than doubled in then Baltic States and Poland in less than ten years and keep increasing very fast. (Table 4)

Table 4. Labour costs, four quarters simple average, index 2000 = 100

	1996	1998	2000	2002	2004
Denmark	85.9	92.5	100.0	108.5	115.9
Germany	91.6	94.5	100.0	104.7	108.6
Estonia	62.7	84.0	100.0	126.9	147.5
Latvia	:	92.3	100.0	116.0	141.4
Lithuania	67.3	94.4	100.0	105.4	114.5
Poland	54.7	82.7	100.0	122.7	131.3
Finland	:	:	100.0	112.1	121.7
Sweden	84.0	92.1	100.0	108.8	117.6
EU25	87.3	93.1	100.0	108.6	116.1

Source: Eurostat 2005.

The desire for a fast increase of labour costs is in the context of relatively low initial levels perfectly understandable, but one must not forget about global competitors, such as the second tier Asian tigers, but also Latin America and others. Thereby, cheap labour cannot be really seen as a major competitive advantage or an argument for future foreign investments into these countries.[9]

It appears that, although all the countries in the region have experienced quite fast economic growth from 1998 onwards, the quality of economic development has been radically different.

9 – For more detailed comparative data on labour costs and productivity by the individual branches of manufacturing industry see Konings 2004.

4. Uneven Quality of Industrial Development

4.1. Increasing Regional Imbalances

The *jobless growth* accompanied by increasing social disparities is only one side of the observable uneven development. A fairly simple comparison reveals that, while the share of medium- and high-tech industries has been increasing in both the manufactured value added and the exports of the Scandinavian countries, Poland and the Baltic States have actually been losing grounds in industrial competitiveness, downgrading their economies in terms of manufactured value added towards more labour and/or resource intensive activities (Table 5).

Table 5. Share of medium- and high-tech industries in industrial value added and exports of manufactures

	% in manufactured VA			% in manufactured exports		
	1980	1990	2000	1980	1990	2000
Denmark	47.7	49.3	54.4	47.9	51.5	53.6
Finland	41.3	47.3	55.9	29.2	42.0	55.2
Sweden	55.2	56.5	66.2	54.7	58.1	65.5
Germany	60.8	66.5	63.2	65.1	68.7	72.0
Estonia	n/a	46.3	38.9	n/a	n/a	47.2
Latvia	49.7	46.3	38.9	n/a	n/a	15.0
Lithuania	n/a	46.3	38.9	n/a	n/a	30.5
Poland	49.4	47.9	38.7	63.7	49.5	46.4

Source: UNIDO 2002.

The Estonian case is particularly interesting. Although nearly 1/4 of the Estonian manufactured exports come from the nominally high tech industries, such as ICT equipment and electronics, the actual value added share of these industries is fairly low, compared to more traditional industries such as wood and wood products or others. Estonia, like Hungary, Mexico or Malaysia, has been successful in attracting foreign direct investments into nominally medium- and high-tech industries, but has actually specialised in these industries in certain low-tech activities such as assembly of electronics or similar. Even if these industries are highly profitable for their owners, the value added produced there is simply transferred out of the Estonian economy (Tiits *et al.* 2006; Tiits *et al.* 2002; Kalvet 2004; Table 6).

Table 6. Value added in million EUR and labour productivity in thousand EUR per person employed, 2002 or most recent year

	Manufacturing						High-tech knowledge int. services	
	Total		High technology		Medium high technology			
	VA	LP	VA	LP	VA	LP	VA	LP
Estonia	1136	9	64	7	106	11	285	24
Latvia	1635	11	:	:	140	9	491	21
Lithuania	1540	6	125	9	:	:	422	20
Poland	38673	16	2498	19	7498	16	:	:
Finland	29655	69	7034	127	5736	57	4735	57
Sweden	43364	55	6518	62	:	:	11506	54
Denmark	25495	56	3915	87	6221	55	6502	65
Germany	401497	55	43734	63	177389	62	71669	68
EU-15	**1450220**	**52**	**188463**	**70**	**456113**	**59**	**355107**	**68**

Note: VA = value added; LP = labour productivity. *Source: Eurostat 2005c.*

The emergence of individual high tech islands in the middle of relatively backward rural areas is by no means unique to Estonia. Over the last decade or two, one can observe developments like this in many parts of the world from the United States or Europe to China or Latin America. Increasing disparities in regional GDP are unfortunately not alien to the Baltic Sea region either. (Table 7)

Table 7. Change in regional disparity of GDP per capita 1995-2002

Country or area (no of regions)		Standard deviation of GDP per capita		Absolute change	Relative change	Disparity at onset	Tendency
		1995	2002	(units)	(%)		
Sweden	(21)	7.9	11.9	4.0	50.7	Small	Increasing
Denmark	(12)	12.8	14.3	1.5	11.8	Small	Increasing
Lithuania	(10)	13.4	24.1	10.7	80.0	Small	Increasing
Poland	(16)	15.1	20.2	5.1	34.1	Small	Increasing
Norway	(18)	15.2	16.2	1.1	7.0	Small	Increasing
Finland	(20)	16.6	19.6	3.0	18.2	Small	Increasing
Russian	(7)	29.0	14.8	-14.3	-49.1	Large	**Decreasing**
Latvia	(5)	29.3	39.2	9.9	34.0	Large	Increasing
Estonia	(5)	34.3	38.9	4.6	13.5	Large	Increasing
German	(7)	39.2	43.3	4.1	10.5	Large	Increasing
Baltic Sea	**(121)**	**16.8**	**22.4**	**3.6**	**18.9**	**Average**	**Increasing**

Note: The data for Norway and Russian BSR are for 1995-2000.

Source: Baltic RIM Economies 2005.

In trying to understand the reasons of diverging developments of individual regions or countries it is very instructive to analyse the public policy responses to the various developmental challenges in their historic context.

4.2. The Nordic Countries

The immensely successful uptake of the opportunities offered by the information and communication technology (ICT) revolution in Finland (and Sweden) owes both to the strong dedication of the Finnish public policy for the development of strong competitive industries and to a strong element of good luck. Although hit hard in the beginning of the 1990s by the double crisis of the loss of the eastern markets and the bust of the domestic real estate and stock market bubbles, the Finnish government stuck to the previous policy strategy for diversification from natural resource intensive industries towards more knowledge intensive ones, such as electronics and ICT. It was realised that the existing industrial specialisation would not allow for a further increase of living standards, and therefore, there is an imminent need to move towards new high-tech and thereby also higher value added activities. This policy strategy remained largely in force even during the deepest crisis: while widespread budget cuts took place elsewhere, the government still increased public investments into R&D, and supported structural change in the economic specialisation of the regions through education and other means (see also Ylä-Anttila and Lemola in this volume).

The Swedish industrial specialisation portfolio is diversified, although it has also been a major player in ICT manufacturing in the 1990s. As is typical of the post-war understanding on the importance of capital accumulation in industry for economic development, the Swedish industrial policy (incl. R&D subsidies to industry, government procurement, etc.) deliberately favoured capital accumulation in large companies and consolidation of industries in the 1970s-1980s.

Yet, Sweden failed to adjust in the post oil crisis situation of the 1980s. Both the public policy stance and the prevalent corporatist practice were interested in preserving the existing *status quo* and did not favour any major changes, however needed for increasing the competitiveness of the Swedish economy (see also chapter V in this volume). This in turn has led to the increasing outward FDI by Swedish multinationals, and the lack of highly qualified workforce at home. Also a series of 'offensive devaluations' of the national currency was officiated to sustain the external balance of the economy and to preserve the cost competitiveness of the dominant industrial conglomerates (Blomström *et al.* 2002).

All in all, Sweden has enjoyed only limited success in exiting the old dominant industries in favour of entering new, more knowledge-intensive industries, but the public policy is strongly there to try to cater for the needs of the multinational corporations based in Sweden. Denmark is a completely different case, as the Danish economy is dominated by relatively small companies specialising in various traditional areas. The typical public policy response in this situation has been to still support various diversification strategies, either based on broad grassroots-level technological learning, attractive design or something else.

In spite of different approaches, each of the Scandinavian countries has been actively enforcing a move towards new and/or an upgrade of the existing traditional industry in its own way.

4.3. The Three Baltic States and Poland

Although Finland and the Baltic States of Estonia, Latvia and Lithuania were among the most industrialised parts of Tsarist Russia, they inherited, when becoming independent at the end of the second decade of the 20th century, a relatively uncompetitive industry. In this respect, the Baltic States found themselves once more in a similar situation after the restoration of independence in the early 1990s.[10]

For the Baltic States, the effects of the collapse of the Soviet Union were not limited to the introduction of their own currencies, but required a rather drastic transformation from the former state-controlled economy to the democratic market economy with all the related complications. While the rest of the ex-USSR economies were still shrinking and unstable, the Baltic States, which had had fairly specialised functions in the Soviet economic system, had lost their main export outlets.

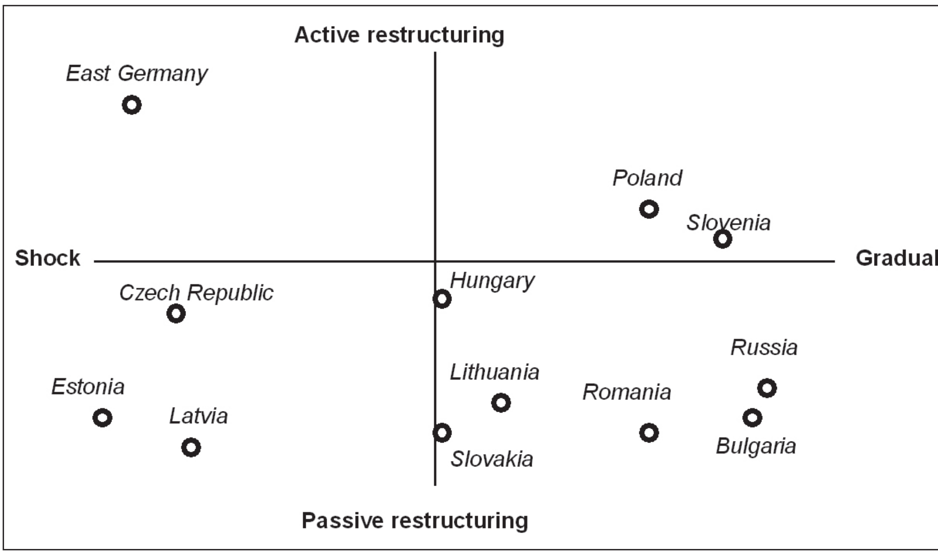
The shift to the Western markets could not take place swiftly either, as the industry needed major investment, and the development of new market niches and the reorientation to the Western markets also needed time. Yet, time was not available to the Baltic States, as for most of Central and Eastern Europe, to cope with these major economic and political changes.

The Estonian and Latvian policy strategies for reintegration into the world economy largely resorted to *shock therapy*. As the industry inherited was considered to be mostly uncompetitive, rapid privatisation to foreign strategic investors was frequently seen as the most feasible approach for both generating foreign exchange revenues needed rather badly, bringing in new organisational practices and technologies, and at the same time also ensuring access to the Western or Nordic markets.

10 – For a more detailed account of the developments in Estonia in the 1920s-1930s, see Kõll and Valge 1998.

The Lithuanian approach to the renovation and privatisation of industry was much more gradualist but still relatively passive, while Russia tried to delay the adjustment with still no support for adjustment. Poland's transition is typically seen in *transition economics* as an exemplary case of *shock therapy*, an approach which the Baltic States, Russia and there others were trying to imitate. However, concurrently Poland and Slovenia appeared to be the only countries in CEE, which attempted to combine their macroeconomic stablisation programmes with active support for the gradual restructuring of industrial R&D from the government. (Figure 5)

Figure 5. Reconstruction of industrial research and development activities in Central and Eastern Europe



Source: Radoševic 1996.

As described earlier in the literature, a rapid liberalisation of markets without time and support for restructuring leads first of all to wiping out the most knowledge- and technology-intensive industries of the relatively less competitive economy. The *Vanek Reinert effect* maintains basically that unequal economic integration on completely free market terms leads to a gradual deindustrialisation of the relatively weaker economy.[11]

This is to an extent, what has also been demonstrated in the 1990s in the Baltic States and Russia. The move away from the plan towards the market was expected to shift Russia's productive structure away from heavy industry and production goods towards consumer goods and light goods. The outcome of the actual transition was quite the opposite – the more technology- and knowledge-intensive industries were wiped out first (Tiits *et al.* 2005).

11 – Reinert has described this as the 'winner-killing effect' and Jaroslav Vanek has called it 'the herbicide effect of international trade' and 'destructive trade'. See Reinert 2004.

Much of the restructuring has already accrued in the Baltic States and Poland through the Europe Agreements, demolishing virtually all trade barriers in the region (except with Russia), and the accession process itself. Therefore, the direct gains resulting from the EU enlargement in May 2004 could have only been quite modest.

Shallow integration (chiefly markets, much less production) into the European economic system, and the closing down of unprofitable enterprises have led to one-time productivity gains and rapid economic growth in the Baltic States. Although industrial output began to increase again in the mid-90s, this has been taking place largely by the increase of labour-intensive and resource-based industries, while high-tech industry has continued to lose grounds. Thus, the industry has become less competitive, while the booming finance, insurance and real estate (FIRE) sectors together with mushrooming domestic consumption funded largely by portfolio inflows and foreign borrowing make the sustainability of the current growth pattern fairly dubious (See also Stephan 2003).

Although we observe the emergence of a closely integrated economic system in the Baltic Sea region, the Nordic countries and Germany specialise in “good trade” while the Baltic States and Poland have been increasingly specialising in “bad trade”, not conductive for a sustained longer-term increase of living standards.

5. Conclusions

Each period of economic difficulties or even a milder crisis offers a window of opportunities for strategy/policy change. Those who are well-prepared in advance, have the highest chances to succeed in reforms, while failure to manage the change properly can easily lead to *destructive destruction*, as opposed to Schumpeterian *creative destruction*, i.e. wiping out the earlier competitive advantages of a country or region, leaving the citizens with next to nothing.

There are three main lines of action that have to be taken into account when designing a broadly-oriented socio-economic development strategy, namely:

- Policies affecting the pressure for change (competition policy, trade policy and the stance of general economic policy);

- Policies affecting the ability to innovate and absorb change (human resource development and innovation policy);

- Policies designed to take care of losers in the game of change (social and regional policies with redistribution objectives). (Table 8)

Table 8. Policy packages affecting the pressure for change and the ability to cope with it in a globalising world

Transformation pressure Macro-economic policy Competition policy ***Trade policy***
↓
Ability to innovate and adapt to change Human resource development policy Labour market policy Innovation policy
↓
Redistribution of costs and benefits of change Tax and other income transfer policies Social policy Regional policy

Adopted from Lundvall and Borrás 1997.

Until very recently, the policy discourse in the Baltic States and Poland, as well as several other CEE countries, have concentrated on the first line of action, i.e. increasing competitive pressures for the inducement of change, while giving much less attention to the other lines of action, which would actually ensure the ability of the enterprises to cope with the change without mounting huge social and regional disparities.

Yet, increasing public subsidies alone are clearly not enough either. The earlier experience of the EU regional policy shows vividly that massive structural aid does not necessarily lead to higher sustained growth.

Integration between economically divergent countries can easily lead to a flow of industrial production from rich to poor and a reverse flow of labour, proving thus a form of *lose-lose integration*, by which neither side benefits in an increase of living standards. But emerging industrial production linkages and corresponding FDI flows between firms in the region may also lead to positive complementary effects in both countries as well. For this to happen, high degrees of vertical specialisation within industries between neighbouring countries in the Baltic Sea region need to offset by creating in each of the countries certain complementary technological and other strengths which would allow for the increase of industrial competitiveness vis-à-vis global competition.

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Creative Destruction Management (CDM) is a term from Schumpeterian economic framework which means that the transition to a new techno-economic paradigm necessarily destroys the old industries, and their associated employment, financial, and other related structures. Within this framework, one of the main tasks of the state is to face the reality and logic of the process of creative destruction, as well as to proactively respond to its predictable challenges, through innovative measures other than regulation. In doing so, the vulnerable people and sectors in the process are integrated into the new paradigm and are taken care of in an optimised way.

Topics covered in the book include the challenges brought about by CDM in the countries of Central and Eastern Europe, economic dimension of nanotechnologies, innovation systems of small countries, transformation of the Finnish innovation system, and industrial dynamics in the Baltic Sea Region since the 1990s.