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Transformation of the Finnish innovation system: A network approach

Sitra Reports series 7

SITRA

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FOREWORD

The world economy has surprised many economists and economic policy makers in recent years. During the 1980s and early 1990s, the growing investments in information and communications technologies had very little impact on aggregate productivity. In the late 1990s, the strong economic growth of the United States did not increase inflation as expected. At the same time, the traditional macro-economic policies proved highly ineffective in Japan: even zero interest rates and large public deficits could not revive the economy from its decade-long recession. Also the empirical studies of economic growth in industrialised countries continued to leave a large unexplained residual. In this year, the economic forecasts of national and international institutions have proved highly over-optimistic and they have revised down their growth estimates by several percentage points in just a few months.

The economic analysts and policy makers are not the only ones surprised by the rapid transformation of the world economy. Indeed, the fundamental transformation of techno-economic environment has challenged *all* decision makers in modern societies. The old mental models, theories and behavioural rules, developed in quite different circumstances, do not work as well today as they did in the past. Moreover, the established social structures and institutions, which are based on these models, theories and rules, face major adjustment challenges. These challenges can only be met if decision makers are willing to fundamentally rethink these structures and institutions in the light of the changed techno-economic environment. Even the most successful institutions can quickly loose their legitimacy and dynamism in the changing environment if decision makers become too satisfied with their old achievements.

The Research Programme on the Finnish Innovation System financed by the Finnish National Fund for Research and Development, Sitra, was motivated by this challenge. The techno-economic environment of the Finnish innovation system has fundamentally changed during the past decade. The current success of the system will not continue in the future if the system is not continuously renewed and upgraded. Such development work requires fresh knowledge about the current

state of the system and its adjustment challenges. This is what the twelve projects of the research programme were aimed to produce and this final report contains.

The adjustment challenge of the Finnish society is *systemic* in nature; the different parts of the society must find a sustainable development path together. Being the most competitive country technologically is not enough. Even having the most competitive innovation system in the world is not sufficient. What is needed is the balanced and rapid development of the whole Finnish society. Only then can we reap the full economic and social benefits of mutually reinforcing elements in the socio-economic system. A similar systemic adjustment explains the success of the Great Britain after the First Industrial Revolution and that of the United States after the Second Industrial Revolution. This calls for a broader concept of innovation; one that includes organisational, institutional and policy-related innovations besides the usual technological ones. Such a broader concept of innovation was adopted in Sitra's research programme.

The systemic transformation perspective led the participants of the programme to ask many new questions about the Finnish innovation system. Why do organisational and institutional innovations offer sustainable bases for competitive advantage? Why have innovation networks become so important in recent years? What is the role of knowledge-intensive business services in the innovation process? What are the new challenges to competition policy and the labour law? Why is coordination important for innovation policy? What are the social costs of technological innovativeness? Many of these questions are new to the Finnish innovation policy discussion. Systemic adjustment proceeds in many fronts and technology is only one of them. The fundamental transformation of the world economy requires a broader definition for the Finnish innovation system and innovation policy.

Sitra wants to thank all the researchers, members of the advisory board and policy makers who contributed to the success of the research programme. We hope that the research and policy networks built during the programme will continue to flourish and spread in the future. The new research programme of the Ministry of Trade and Industry and TEKES provides an ideal base for this.

Helsinki, 30 September 2001

Timo Hämäläinen
Director of Innovative Operations
Finnish National Fund for Research and Development, Sitra

Suomenkielinen tiivistelmä

SUOMEN INNOVAATIOJÄRJESTELMÄN RAKENNEMUUTOS: VERKOSTONÄKÖKULMA

Maailmantalouden murros muuttaa kehittyneiden teollisuusmaiden yhteiskuntarakenteita nopeasti ja perusteellisesti. Termit 'tietoyhteiskunta', 'osaamisyhteiskunta' ja 'verkostoyhteiskunta' kuvaavat tämän rakennemuutoksen suuntaa sekä korostavat tiedon ja innovaatioiden merkitystä uudessa talousjärjestelmässä. Rakennemuutoksen keskeisiä taustavoimia ovat talouden globalisoituminen, markkinoiden vapautuminen ja sääntelyn vähentyminen, uuden tietoteknologian läpimurto, tieteen ja tutkimuksen uudet saavutukset sekä kysyntärakenteessa tapahtuneet muutokset.

Nämä muutosvoimat haastavat myös Suomen innovaatiojärjestelmän uudistumaan. Viime vuosien menestyksestä huolimatta kansallista innovaatiojärjestelmää on jatkuvasti kehitettävä, jotta sen elinvoimaisuus ja kilpailukyky säilyisivät nykyisellä korkealla tasollaan. Tämä oli myös Sitran *Kansallisen innovaatiojärjestelmän tutkimusohjelman* tärkein päämäärä. Tutkimusohjelma toteutettiin elokuun 1999 ja helmikuun 2001 välisenä aikana ja siihen osallistui 12 tutkimushanketta eri puolilla Suomea. Nämä tutkimushankkeet edustivat useita eri tieteenaloja (taloustiede, sosiologia, psykologia, lakitiede, kasvatustiede, jne.): tarkoituksena oli saada uusia näkökulmia suomalaiseen innovaatiojärjestelmään. Tämä raportti vetää yhteen Sitran tutkimusohjelman tärkeimmät tulokset ja johtopäätökset.

Maailmantalouden murros on lisännyt kansantalouden toimintaan liittyvää epävarmuutta. Yritykset ovat vastanneet tähän haasteeseen erikoistumalla entistä pidemmälle toiminnassaan sekä panostamalla yhä enemmän uusien innovaatioiden kehittämiseen. Tämä on lisännyt tutkijoiden ja poliittisten päättäjien kiinnostusta kansallisen innovaatiojärjestelmän (national innovation system) käsitettä kohtaan. Tämä käsite korostaa innovaatiotoiminnan ja yhteiskunnan laaja-alaisen *sys-*

teemisen uudistumisen keskeistä merkitystä talouden kehityksen ja kasvun kannalta. Toisaalta Suomessa tiedetään melko vähän innovaatiojärjestelmän suhteesta yhteiskunnan muihin osajärjestelmiin. Tällaisia ovat mm. koulutus-, työmarkkina-, lainsäädäntö- ja ekologinen järjestelmä. Näistä suhteista tarvitaan lisää tutkittua tietoa.

Historiallisen murroksen aikana kansantalouksien kilpailukyky riippuu siitä, (a) miten lähellä niiden olemassa olevat talous- ja yhteiskuntarakenteet ovat uuden teknis-taloudellisen toimintaympäristön asettamia vaatimuksia (starting point) ja (b) miten nopeasti ne pystyvät uudistamaan näitä rakenteita uuden toimintaympäristön vaatimaan suuntaan (adjustment capacity). Murrokseen nopeasti ja tasapainoisesti sopeutuvat maat pääsevät hyötymään uuteen teknis-taloudelliseen järjestelmään liittyvistä 'kasvavista tuotoista' ja nopeasta talouskasvusta. Nämä kasvavat tuotot liittyvät talous- ja innovaatiojärjestelmien lukuisiin sisäisiin riippuvuussuhteisiin ja positiivisiin takaisinkytkentöihin, jotka korostavat muutoksen systeemistä luonnetta. Hitaasti tai epätasaisesti sopeutuvat yhteiskunnat eivät pääse nauttimaan em. kasvavista tuotoista ja alkavat jäädä taloudellisesti jälkeen maailmantalouden eturivin maista.

Suomi on sopeutunut maailmantalouden murrokseen erittäin nopeasti. Se on monella rakenteellisen kilpailukyvyn mittarilla mitattuna aivan maailman kärkimaiden joukossa. Tämä selittää pitkälti myös Suomen nopean talouskasvun viime vuosina. Suomella näyttääkin pienenä ja kulttuurisesti yhtenäisenä maana olevan kilpailuetu yhteiskunnan laaja-alaisessa uudistamisessa moneen suurempaan ja monikulttuurisempaan maahan verrattuna. Toisaalta Suomen viimeaikaista uudistumiskykyä selittää myös 1990-luvun alussa koettu syvä talouskriisi, joka pakotti suomalaiset päätöksentekijät luopumaan vanhentuneista ajattelu- ja toimintamalleistaan sekä sai heidät hyväksymään aiempaa rajumpia rakenteellisia uudistuksia. Laman muistojen hiipuessa suomalaisten päätöksentekijöiden tulisi kiinnittää entistä enemmän huomiota yhteiskunnan rakenteelliseen uudistamiseen mm. koulutuksen, kilpailuedellytysten, infrastruktuurin, työmarkkinoiden, sosiaaliturvan ja yhteiskunnallisen sääntelyn alueilla, jotta yhteiskunnalliset uudistukset eivät jäisi Suomessa jälkeen kansainvälisen toimintaympäristön vaatimuksista. Talouspolitiikassa tämä tarkoittaa huomion kiinnittämistä erityisesti elinkeino- ja rakennepolitiikkaan.

Merkittävät innovaatiot eivät enää synny yksittäisten keksijöiden päissä kuten joskus ennen. Yritysten innovaatioprosessit ovat nykyään luonteeltaan erittäin monimutkaisia ja epävarmoja. Niihin osallistuu yleensä useita eri asiantuntijoita ja organisaatioita tutkimuksen, kehitystyön, tuotannon, markkinoinnin ja innovaation loppukäyttäjien joukosta. Innovaatioprosessit eivät myöskään ole lineaarisia tutkimuksesta kaupallistamiseen asteittain johtavia ketjuja vaan lukuisia takaisinkytkentöjä ja vuorovaikutussuhteita sisältäviä monimutkaisia verkostoja. Innovaatioverkostot olivatkin Sitran tutkimusohjelman keskeinen tutkimuskohde.

Innovaatioiden käyttäjien rooli on korostunut moderneissa innovaatioprosesseissa. Uusien innovaatioiden pitää sopia käyttäjien toimintaympäristöön ja merkitysmaailmaan tullakseen hyväksytyiksi markkinoilla. Käyttäjät osallistuvat yhä use-

ammin myös itse innovaation kehittämiseen. Tästä tarjoaa hyvän esimerkin ns. open source -kehittämismalli, jonka merkitys on kasvanut tietokoneohjelmistojen (esim. Linux) ja Internet-pohjaisen liiketoiminnan kehittämisessä.

Suomessa on perinteisesti korostettu teknologisia innovaatioita. Talouden ja yhteiskunnan laaja-alainen rakennemuutos kasvattaa kuitenkin myös sosiaalisten innovaatioiden merkitystä. Sosiaalisiin innovaatioihin kuuluvat mm. uudet organisatoriset ratkaisut, institutionaaliset toimintapuitteet (normit, lait, sääntely), toimintamallit ja käsitteelliset viitekehikot, jotka ratkaisevat aiempaa paremmin ongelmia. Ilman sosiaalisia innovaatioita yhteiskunta ei voi päästä nauttimaan uuteen toimintaympäristöön liittyvistä kasvavista tuotoista ja nopeasta talouskasvusta. Kilpailijoiden on myös usein vaikeampi kopioida sosiaalisia innovaatioita kuin teknologisia innovaatioita, minkä vuoksi ne tarjoavat kestävän pohjan yritysten ja kansakuntien kilpailukyvylle.

Osaamisintensiivisillä liike-elämän palveluilla (tutkimus, tekninen suunnittelu, liikkeenjohdon konsultointi, tietohallinto, lakiasiat jne.) on keskeinen rooli innovaatiojärjestelmässä. Ne luovat ja levittävät uutta tietoa asiakkaidensa keskuudessa. Valitettavasti tällaiset palvelut ovat Suomessa kilpailukykyisiä vain muutamilla aloilla (IT- ja metsäsektorit). Yleensä tämän alueen yritykset ovat Suomessa melko pieniä, alueellisesti suuntautuneita sekä kansainvälisesti kilpailukyvyttömiä.

Uuden tiedon luomisen ja innovatiivisuuden katsotaan usein keskittyvän ns. korkean teknologian aloille, jotka tekevät paljon tutkimus- ja kehitystyötä. Tämä ei kuitenkaan pidä paikkansa, sillä paljon innovaatioita ja oppimista tapahtuu myös kypsemmillä toimialoilla, joissa on keskimääräistä vähemmän t&k-toimintaa. Näillä toimialoilla innovaatioprosessien luonne kuitenkin eroaa merkittävästi korkean teknologian sektoreista. Tällaisia sektorikohtaisia eroja innovaatioprosessien luonteessa pitää innovaatiopolitiikassa ottaa aiempaa enemmän huomioon, kun uusi teknis-taloudellinen järjestelmä leviää laajemmalle kansantaloudessa.

Uuden tietoteknologian käyttöönotto voi merkittävästi parantaa organisaatioiden tehokkuutta ja innovatiivisuutta, mutta tämä edellyttää samanaikaista panostusta uusiin organisaatiomalleihin, työntekijöiden osaamiseen sekä organisaatiokulttuuriin. Organisaatioiden tulee olla hajautettuja ja joustavia, jotta ne tukevat tiedonkulkua ja työntekijöiden välistä kanssakäymistä. Oppimaan oppimisen taito on tärkein yksittäinen 'ammattitaito' nopeasti muuttuvassa toimintaympäristössä. Uutta oppivaa organisaatiomallia tukee parhaiten vahva, tiedon jakamista ja levitystä tukeva yrityskulttuuri.

Verkostoyhteistyöllä on selkeitä etuja innovaatiotoiminnan organisoinnissa verrattuna hierarkkiseen tai markkinoihin perustuvaan organisaatiomalliin. Verkostossa organisaatiot voivat erikoistua ydinosaamisalueilleen ja hankkia tarvittavat lisätiedot ja -resurssit verkoston muilta organisaatioilta. Luottamukseen perustuvat verkostosuhteet tukevat ns. hiljaisen tiedon vaihtoa organisaatioiden kesken, mikä on keskeinen edellytys innovaatioprosessien onnistumiselle. Tällaista tietoa ei voida siirtää löyhissä markkinasuhteissa. Toisaalta hierarkkiset organisaatiot eivät enää pysty hankkimaan itselleen kaikkea merkittävien innovaatioiden vaatimaa tietoa entistä erikoistuneemmassa ja dynaamisemmassa teknologiaympäristössä.

Sosiaalisella pääomalla on tärkeä merkitys innovaatioverkostojen muodostumisen, toiminnan ja tuloksellisuuden kannalta. Vahva sosiaalinen pääoma ja yhtenäinen kulttuuri ovat luoneet verkostoyhteistyölle ja innovaatiotoiminnalle suotuisan maaperän Suomessa. Toisaalta nämä tekijät voivat myös toimintaympäristön muuttuessa muodostaa esteitä talouden ja yhteiskunnan uudistumiselle, jos vahvat verkostosidokset ja erityisintressit sitovat organisaatioita vanhoihin toimintamalleihin ja yhteistyökumppaneihin ja hidastavat näin rakennemuutosta. Verkostoihin liittyy siis omat organisatoriset heikkoutensa (network failures), aivan kuten yrityshierarkioihin (bureaucratic failures), markkinoihin (market failures) ja julkisen sektorin organisaatioihin (government failures).

Suomalaisessa innovaatiopolitiikassa on perinteisesti korostettu uuden tiedon tuottamista ja kansakunnan osaamispohjan vahvistamista. Maailmantalouden murros edellyttää laajempaa, *systeemistä innovaatiopolitiikkaa*, jossa pyritään parantamaan innovaatiojärjestelmän kaikkia heikkoja osa-alueita. Tällaisia järjestelmän toimintaan liittyviä ongelma-alueita (systemic failures) voi löytyä tiedon ja osaamisen ohella mm. infrastruktuurista, talouden ja yhteiskunnan organisaatiorakenteista, eri sektorien ja markkinoiden kilpailutilanteesta, institutionaalisista toimintapuitteista (normit, lait, sääntely) sekä poliittisten toimenpiteiden koordinaatiosta. Systeeminen innovaatiopolitiikka lähestyykin sisällöltään elinkeino- ja rakennepolitiikkaa. Klusteripolitiikka on tästä hyvä esimerkki Suomessa.

Systeemisen innovaatiopolitiikan toinen keskeinen ominaisuus on innovatiivisten yhteistyöverkostojen kehittäminen. Verkostopolitiikasta (network-facilitating policy) on viime vuosina tullut tärkeä osa teollisuusmaiden innovaatiopolitiikkaa. Verkostopolitiikalla voidaan pyrkiä yhdistämään innovaatioprosessin eri vaiheita (perustutkimus, design, kansainvälinen markkinointi jne.) sekä erityyppisiä organisaatioita (yrityksiä, yliopistoja, julkisen sektorin organisaatioita, järjestöjä jne.), toimialoja ja maantieteellisiä alueita (paikallinen, alueellinen, kansallinen ja kansainvälinen taso). Vaikka Suomessa on pitkään kehitelty yritysten verkostoimiseen sopivia politiikkatoimenpiteitä, ei verkostopolitiikkaan vielä ole saatu kokonaisvaltaista otetta ja koordinaatiota. Verkostoimistoimenpiteitä ja -ohjelmia tehdään vielä hyvin itsenäisesti julkishallinnon eri organisaatioissa eivätkä saadut käytännön kokemukset leviä kunnolla muihin samalla alueella toimiviin organisaatioihin. Sama pyörä saatetaan keksiä useampaan kertaan eri organisaatioissa. Verkostopolitiikan tekijöiden kesken tarvitaan selkeästi enemmän vuorovaikutusta ja koordinaatiota.

Suomi on pieni maa ja suurin osa maailman innovaatioista syntyy maamme rajojen ulkopuolella. Tämän vuoksi kyky tunnistaa, analysoida, omaksua, levittää ja hyödyntää ulkomaisia teknologisia, taloudellisia ja sosiaalisia innovaatioita on Suomelle erittäin tärkeää. Ulkomaisten innovaatioiden löytymistä ja hyödyntämistä voidaan tukea mm. benchmarking- sekä teknologian ennakointi- ja arviointitutkimuksin. Tällaisia tutkimuksia ei vielä ole systemaattisesti hyödynnetty Suomen innovaatiopolitiikan kehittämisessä. Uusien politiikkainnovaatioiden kehittämistä voidaan myös tukea poliittisia päätöksentekijöitä ja asiantuntijoita verkostoimalla. Politiikkaverkostot (policy networks) hyödyntävät laajalti yhteiskunnan eri sekto-

reilla ja tasoilla olevien asiantuntijoiden tietoja ja osaamista. Tällaisia verkostoja voidaan käyttää laaja-alaisten ja monimutkaisten yhteiskunnallisten ongelmien ratkaisussa (esim. koulutusjärjestelmän uudistaminen, nuorten kehitysongelmat, epätasainen aluekehitys jne.).

Suomalaisen yhteiskunnan menestys riippuu sen laaja-alaisesta uudistumiskyvystä. Tämä korostaa myös talouden perinteisten sektorien — perusteollisuuden ja palveluiden — uudistumistarvetta ja innovaatiotoimintaa. Yhteiskunnan eri sektoreiden innovaatioprosessien luonteessa olevat erot vaativat innovaatiopolitiikalta sektorikohtaista herkkyyttä, klusteriohjelmat ovat tästä hyvä esimerkki. Myös osaamisintensiivisten liike-elämän palveluiden kehittäminen ja integroiminen osaksi Suomen innovaatiojärjestelmää näyttää edellyttävän omia politiikkatoimenpiteitään.

Toimintaympäristön muuttuessa nopeasti kansallisen innovaatiojärjestelmän kehittäminen vaatii entistä enemmän tutkittua tietoa. Innovaatiotoimintaa ja -järjestelmää koskeva tutkimusperinne ei ole ollut Suomessa yhtä vahva kuin muissa Pohjoismaissa. Tällaista tutkimusta on tärkeää vahvistaa lähivuosina. Sitran tutkimusohjelma saakin heti jatkoa Kauppa- ja teollisuusministeriön ja TEKESin uudessa tutkimusohjelmassa. Koska innovaatiojärjestelmää koskevaa tutkimusta tehdään usean eri tiedekunnan alueella, olisi niiden välille pyrittävä rakentamaan aiempaa enemmän siltoja ja yhteistyötä. Sekä innovaatio- että tutkimusprosessit hyötyvät poikkitieteellisestä yhteistyöstä. Tutkimusverkostoihin tulee myös mahdollisuuksien mukaan pyrkiä liittämään ulkomaisia tutkijoita ja tutkimuslaitoksia.

1 INTRODUCTION

This study presents a synthesis of the main results of Sitra's Research Programme on the *National Innovation System in Finland*. The other key goal of the programme was to develop a better understanding of the nature and functioning of modern innovation processes. The nature of innovation processes has changed and policy makers need to have a deeper understanding of their dynamics in order to focus their activities on the most relevant problems and to choose the best policy instruments available. This is particularly important now that the Finnish innovation system is, in many respects, at the frontier of technological and economic development and policy makers cannot anymore follow the example of more successful countries. The other key goal of the research programme was to identify new policy challenges to the Finnish innovation system. Despite its current success, the national innovation system must be continuously improved and renewed to meet the challenges of the rapidly changing techno-economic environment. As a result, the study includes theoretical, empirical and policy-oriented analysis. The more policy-oriented readers may want to focus on the last two chapters (Ten and Eleven) where we discuss the policy-implications of the study. The theoretical and empirical analysis is mainly included in the earlier chapters (Two through Nine).

Despite its broad scope, Sitra's research programme could not hope to provide a systematic evaluation of the strengths and weaknesses of the Finnish innovation system. This would have been too heroic an attempt. Instead, the programme focused on two core themes in the innovation system. These underlying themes of the whole programme were the current *techno-economic transformation of the world economy* and the *nature and dynamics of modern innovation processes*.

The programme included 12 research projects in different Finnish universities and research institutes. The researchers represented various scientific disciplines ranging i.a. from economics to psychology, and from sociology of knowledge to law and pedagogics. Hence the programme developed multiple perspectives to the current transformation and its challenges. The interdisciplinary nature of the programme, of course, posed its own practical challenges as scholars from very

different traditions and scientific paradigms tried to understand each other's contributions and cooperatively develop new insights. Hopefully, these cooperative processes can be continued and further developed in the future.

The research programme has encouraged international cooperation as much as possible. Although most of the research was carried out in Finland, important parts of many projects were also done at or in cooperation with foreign research institutions. Moreover, the following distinguished foreign professors were invited to Finland to participate in the programme's semi-annual research seminars and to comment on the preliminary findings of the different research projects: Professor J. Rogers Hollingsworth (University of Wisconsin, Madison, USA), Professor Keith Pavitt (University of Sussex, SPRU, UK) and Professor J.-C. Spender (School of Business and Technology, Fashion Institute of Technology, New York, USA). Professor Erkko Autio from the Helsinki University of Technology also visited a day-long programme meeting to comment on the progress of the research projects. We are very grateful for the insightful comments and guidance that our distinguished commentators provided for the project teams. Finally, the authors of the present report actively participated in the work of the OECD's Focus Group on Innovative Firm Networks, as a part of the research programme.

The programme was prepared in a preliminary study during the summer and autumn of 1998 by Gerd Schienstock and Osmo Kuusi. The preliminary study was concluded with an international seminar where leading Finnish and foreign innovation researchers presented their papers on the future challenges of the Finnish innovation system and innovation research in general. These papers were subsequently published as a book *Transformation Towards a Learning Economy: The Challenge for the Finnish Innovation System* (edited by Schienstock & Kuusi 1999, Sitra 213). The preliminary study raised a dozen of key research challenges for Sitra's research programme. The prominent Advisory Board of the programme then helped Sitra further to focus the research programme on a few key areas. Their advice was then reflected in the nature of the chosen projects and ultimately in the structure of this synthesis report. The Advisory Board consisted of the following members:

Mr Markku Linna, Secretary General, Ministry of Education, Chairman
Mr Jarl-Thure Eriksson, Rector, Tampere University of Technology
Mr Tapani Haikola, Vice-President, Diarc-Technology Inc.
Mr Eero Kasanen, Rector, Helsinki School of Business and Administration
Mr Tarmo Lemola, Research Manager, Technical Research Center of Finland (VTT)
Mr Erkki Ormala, Director, Nokia
Mr Antti Piippo, Chairman of the Board, Elcoteq Network Corporation
Mr Jari Romanainen, Strategy Director, The National Technology Agency (Tekes)[1]
Mr Esko-Olavi Seppälä, Chief Planning Officer, Science and Technology Policy Council of Finland

[1] Mr Martti Mäenpää, President, preceeded Mr Romanainen as the representative of the National Technology Agency (Tekes) in the Advisory Board.

Mr Gerd Schienstock, Professor, University of Tampere
Ms Vappu Taipale, Director General, National Research and Development Centre for Welfare and Health (Stakes)
Mr Reijo Vihko, President, Academy of Finland
and
Mr Antti Hautamäki, Research Director, Finnish National Fund for Research and Development (Sitra)
Mr Timo Hämäläinen, Development Manager, Finnish National Fund for Research and Development (Sitra)

Sitra's research programme on the Finnish innovation system began in August 1999. Professor Gerd Schienstock from the University of Tampere was appointed as the scientific director of the programme. From Sitra's side, the project was co-ordinated by Dr. Timo Hämäläinen. The following projects were selected to participate in the programme:

1. Kai Hakkarainen (University of Helsinki), Erno Lehtinen (University of Turku), and Tuire Palonen (University of Turku): *The Development of Networked Expertise*.
2. Ilkka Tuomi (Nokia/University of Berkeley): *The New Dynamics of Competence Clusters and Innovation Networks*.
3. Erkki Kaukonen and Mika Nieminen (University of Tampere): *The Changing Role of Research and Networking in the National Innovation System.*
4. Ilpo Koskinen, Peter McGrory, and Tanja Kotro (University of Art and Design, Helsinki): *Managing the Interface between Industrial Design and Manufacturing Organisations: Benchmarking International Best-Practice.*[2]
5. Aija Leiponen (ETLA, Helsinki): *Knowledge-Intensive Business Services: Innovation and Interaction with the Manufacturing Sector.*
6. Tarmo Lemola and Christopher Palmberg (VTT Helsinki): *Low-Tech Innovation and Industrial Renewal.*
7. Gerd Schienstock, Sirpa Kolehmainen, Pasi Tulkki and Anu Järvensivu (University of Tampere, Work Research Centre): *The Emergence of Knowledge-Intensive Industries.*
8. Reijo Miettinen (University of Helsinki): *Multidisciplinary Research and Technology Policy.*
9. Reijo Raivola, Kari Kekkonen, Pasi Tulkki, and Anu Lyytinen (University of Tampere): *Production Competencies in a Network of Education and Industries.*
10. Asko Suikkanen (University of Lapland, Department of Social Science): *The New Millennium and Transitions in the Labour Markets.*
11. Kalle Määttä (University of Joensuu): *Regulatory Reforms and Innovations: Whether to Trust Invisible Hand or Use Invisible Hand?*
12. Seppo Koskinen and Hannu Mikkola (University of Lapland): *The New Work and Labour Law.*

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[2] Peter McGrory left the project before its completion. He was replaced by professors Pekka Korvenmaa and Juhani Salovaara.

It was not possible to produce a well-structured and readable synthesis report only by compiling an edited summary of the different, quite heterogeneous, project reports. Instead, the authors of the present study have chosen to write a coherent report of their own which includes the results of the 12 projects as extensively as possible. The authors' own research and other research findings have been included where necessary to meet the programme's original goals. Although all research groups agreed on the importance of the core themes of the programme, the statements in the report do not necessarily reflect their views, nor do they necessarily agree on the authors' interpretation of specific change processes or their policy conclusions.

The report is structured as follows. In Chapter Two, we analyse the nature and driving forces of the current techno-economic transformation. In Chapter Three, we present a brief theory of catching up and forging ahead in economic growth and analyse the post-war growth and structural change of the Finnish economy. The empirical benchmarking analysis emphasises the current strengths of the Finnish economy and highlights a few structural challenges that call for further innovation and renewal. In Chapter Four, we discuss several aspects of the innovation concept. We suggest a wider concept of innovation, including not only technical but also social innovations. We also stress the importance to analysing innovation as a social process, which involves individual and organisational learning. Finally, we analyse the concept of communities of practice and the open source model as new perspectives on the innovation process.

Chapter Five focuses on the national innovation system model (NIS). The NIS is defined as a system that creates, diffuses, and applies knowledge. We examine several unresolved questions in the innovation system approach, such as the identification of actors and the drawing of boundaries in the innovation system, the problem of system governance and the appropriate level of analysis. We also discuss new perspectives and topics, such as the need to analyse the innovation system in its wider economic and social context, the role of KIBS firms in the innovation system, and the perspective of path creation.

In Chapter Six, we examine the extent to which innovation processes differ in the low-tech, high-tech and KIBS industries. We stress the importance of inter-sectoral cooperation in innovation processes. Chapter Seven in turn focuses on intra-firm restructuring. The use of modern ICT, organisational restructuring, trust-based organisation culture, and new skills and competencies are discussed as core elements of firms' restructuring processes. Chapter Eight examines the economic rationale behind increasing inter-firm networking and the comparative advantages of networks in relation to markets and hierarchies in particular.

Chapter Nine will focus on the institutional framework of innovation processes in Finland such as: the higher education system (universities and polytechnics), the competition and labour laws, the labour market and work regulations. Here we discuss two aspects: how these institutions affect the innovation system and what changes are needed to make these systems more effective. We will also deal with possible negative consequences of knowledge-based innovation processes.

Modern innovation processes call for new types of policies. Chapter Ten deals with the new 'network-facilitating policies' pursued in many OECD countries. We analyse international approaches to network-facilitating policy and compare them with Finnish policy examples. We further argue that the innovation system concept suggests benchmarking as a key tool for policy learning. The concluding Chapter Eleven points to some key challenges to the Finnish innovation policy based on the modern innovation literature and on the empirical findings of the Sitra's research programme. We also identify some areas in which further research is necessary.

2 SYSTEMIC TRANSFORMATION CHALLENGE

In this chapter, we will take up the argument that we are currently in the middle of a fundamental economic transformation process. Concepts such as 'knowledge economy', 'learning economy' and 'network economy' all stress important features of the *emerging,* new socio-economic formation, but all the changes they highlight do not necessarily characterise a fundamental transformation process. In some cases, they may actually represent more gradual changes depending on earlier socio-economic preconditions. We will further argue that in order to better understand current change processes, we have to examine those forces that drive and enable them.

The transformation argument

There is wide agreement that after a long period of slow and steady socio-economic change we are now living through one of the rare intervals in history, in which economy and society are being *transformed fundamentally and rapidly* (Gould 1980). The current transformation may become even more dramatic than its historical predecessors – e.g. the transformation of the agrarian into the industrial economy – because the change process will take place in a *much shorter period of time* (High Level Group on the Information Society 1996).

The argument of a radical socio-economic change, however, is not a new one. Some thirty years ago, Daniel Bell (1973) and Allan Touraine (1969) spoke about the transformation of the industrial into a *post-industrial society*. Bell himself subsequently claimed *knowledge as the new axial principle* of the emerging society. Other authors, taking up the argument of a fundamental transformation process

have characterised the developing new socio-economic formation as 'information society' (Brotchie et al. 1987), 'science society' (Drucker 1969), 'knowledge society' (Böhme and Stehr 1986), 'learning society' (Lundvall and Johnson 1994) and 'network society' (Castells 2000). Recently the concept of 'New Economy' has also entered the debate (Soete 2001).

The OECD has in recent years been emphasising the move towards a *knowledge-based economy* (1996a, 2000a; Foray and Lundvall 1996). In an increasing number of economic fields, it is argued, flows of goods are or will be soon replaced by flows of information and knowledge. The fastest growing countries and regions are those that manage to generate and diffuse knowledge most rapidly. The knowledge economy is defined by the OECD (1998a) as an economy that is directly based on the production, distribution and use of knowledge and information. At the heart of the discussion about the knowledge economy is the argument that *innovation*, which results from the application of technical and other knowledge, is a major contributor to industrial competitiveness (Boden and Miles 2000). The knowledge economy, we can conclude, is an *innovation-driven economy*.

Lundvall and Archibugi (2001) refer to the '*learning economy*' as a slightly different concept. They argue that it is not the increasing stock of specialised knowledge in the first place that characterises the emerging economy but the *acceleration of both knowledge creation and knowledge destruction.* As individuals and institutions are increasingly confronted with rapid changes, they need to renew their competencies more often than before. At the same time the accelerating change process affects more and more parts of the economy and society. Thus it is individuals' and organisations' capacity to learn — and to forget — that decides about economic success.

Castells (2000) sees a *deeply interdependent economy* emerging, in which the *network* is becoming the dominant governance form. He argues that under the new historical conditions productivity is generated through and competition is played out in a global network of interacting business networks. The network concept also stresses the importance of *relational capital* (Storper 1997) or *social capital* (Putnam 1993) for knowledge creation and innovation processes.

There are critics that challenge the thesis of a fundamental economic transformation, however. One argument is that although production is increasingly knowledge-based, economic processes are still following the *traditional economic logic*. One can also argue that so far all economies have been knowledge economies (Miles and Robins 1994) and therefore, instead of assuming a fundamental transformation, it might be more adequate to talk about *gradual changes within the existing economy*. One can, on the other hand, criticise the thesis of a gradual development for interpreting current changes according to a model derived from the assumed past changes (Kumar 1995), which makes it difficult to grasp 'the new'.

There is no doubt that the above-mentioned concepts characterise important features of the emerging new economy. There is, however, always the danger that such general concepts *overemphasise convergence and underestimate divergence*. We have to understand the above-mentioned concepts as representing a *general*

socio-economic paradigm, which allows for *different national trajectories*, as it is the case with the current industrial society. Then in some cases the current transformation may be seen as a total break from the traditional economic structure while in others we may have the impression of a more gradual change process. It then becomes important to focus more on the *driving forces* behind the transformation process.

Driving forces

The fact that knowledge and innovation have become so central to the emerging new economy can be attributed to several factors. These factors operate differently; while some of them put great pressures on economic actors to improve and accelerate innovation processes, others open up growing opportunities to innovate. Both *growing opportunities and increasing challenges* have enhanced the uncertainty and turbulence in the economy, which has given innovation a dominant role in the creation of economic growth and social welfare.

Among the challenges, the *globalisation of markets* is the most important factor, as it stimulates innovation competition. *Liberalisation and deregulation* of markets and financial flows have paved the way for globalisation competition. Foreign direct investment has contributed to the diffusion of knowledge. On the other hand, the *dynamic scientific and technological development* has increased innovation opportunities, although there is no linear relationship between science and innovation. Changing demand patterns, including particularly the need to create new demand and markets, also open up new innovation opportunities. And *modern information technology* has contributed to the creation of new innovative opportunities by broadening and accelerating knowledge flows[3]. In the following, we will first deal with the increasing challenges caused by globalisation and deregulation. We will then turn our attention to the role of modern ICT in innovation processes. Finally, we will discuss the increasing innovation opportunities related to the dynamic development of scientific and technological knowledge as well as to changing demand patterns.

Global competition and increasing innovation pressures

Economic globalisation[4] can be seen as a key factor that puts pressure on companies, regions, and nations to innovate more rapidly and frequently. Globalisation, however,

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[3] Galli and Teubal (1997) mention globalisation, liberalisation, dematerialisation, and the technological revolution as main trends.

[4] In the following, we will mainly concentrate on the economic aspects of globalisation, although it also has a political, cultural, ecological, and technological dimension.

is neither caused by an abstract logic of continuous growth or by the law of 'economies of scale'. It was triggered by the political decision of governments to deregulate their economies (Hirst and Thompson 1996). Without the conclusion of various international agreements actively promoting the process during the last decades, globalisation would have hardly progressed as much as it did in the past.

Globalisation can be characterised as a new stage in the development of economies; while internationalisation points to an increasing border crossing of economic activities, globalisation implies the merging of national markets into one unbounded world market. It signals a *growing integration and interpenetration of economic activities* on a world-wide scale. More critical scholars, however, argue that economic globalisation has progressed less rapidly; we are still far away from a truly global economy.[5]

There is no doubt that, together with the establishment of the so-called 'information highway', interconnections between geographically different parts of the world have increased very rapidly. But only in some areas and industries has globalisation developed very fast, while in others more related to *competence building* and *innovation* national boundaries still remain very crucial (Archibugi and Iammarino 2001).

Globalisation is of particular importance for explaining industrial dynamics as it changes 'the rules of the competition game'. Globalisation makes price and cost competition more intensive as national monopolies and oligopolies break down. Competition is not diminishing although presence in global markets requires enourmous resources, which increases the entry barries for small firms. Besides growing price and cost competition, *new competition criteria* — such as quality and time — have become increasingly important for firms' competitiveness. Nowadays, all global players must be capable of producing high-quality products on a low cost base, of selling them for a reasonable price and of delivering them in time (Stahl et al. 1993, 15). The slogans towards 'quality-based', and more recently, 'time-based' competition expresses this shift (Murray and Willmott 1995, 166).

However, the above competition criteria are only entry barriers to the global market, while economic success increasingly depends on companies' *ability to innovate rapidly and continuously* and to develop new products that meet the demands of the customers in the first place. In global markets, companies can no longer expect that their successful products and practices of the past will keep them viable in the future. Those companies that are first to the market with new and innovative products enjoy first-mover advantages and collect premium prices as long as their competitors have not caught up with them (Hage and Alter 1997).

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[5] Soete and van ter Weel (1999) differentiate between old and new globalisation. They argue that, from a more institutional perspective, globalisation has reached an unprecedented phase, even if trade flows are not unprecedented and even if FDI flows remain centred among the most developed economies.

Therefore, companies are forced to *embody a philosophy of continuous improvement and innovation.* Instead of focusing on cost cutting only, they have to think in terms of growth and value-added through knowledge creation and knowledge application in innovation processes. Actually, companies have to combine the ability to produce the required amount of quality products, just in time, within a reasonable cost framework with the capacity to quickly and continuously innovate. "Companies now *require* quality, value service, innovation and speed to market for business success, and these factors will be even more critical in the future" (Davenport and Prusak 2000, 13, emphasis original).

The concept of techno-globalism subsumes several trends that influence the generation and diffusion of technological and other innovations (Archibugi and Michie (1997):

- firms' attempts to exploit their innovations in the global market;
- collaboration across borders among public and private organisations to exchange and develop know-how; and
- development of innovations across several nations within multinational enterprises.

It is beyond dispute that the first two dimensions of globalisation of technology have grown in importance. There is less evidence, however, for multinational corporations having increased their technological operations in host countries. In the locational choices for their strategic assets, such as technology, global companies seem to be loyal to their home country (Patel 1998).[6] Empirical research shows that most transnational technology development activity of corporations "is *either* local design modification to meet specifications and regulations or research to facilitate monitoring of local science and technology" (Archibugi and Michie 1997, 40).

Deregulation and liberalisation of markets

The liberalisation of financial markets and trade can be seen as an important part of a general political trend towards deregulation. The *liberalisation of the financial markets* and the abolishment of control on capital movement definitely have an enormous influence on the economic transformation towards an innovation-driven and knowledge-based economy (OECD 1990). Due to a growing integration of financial markets and on the basis of sophisticated ICT systems, global flows of finance have increased dramatically in their volume, in their velocity, and in their complexity (Chesnais 1994; Webster 1995). The development of an integrated global financial market reduces the dependence of companies' investment and innovation strategies on the capacity of their national financial markets, as finance

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[6] Cantwell (1997) argues, however, that from a historical perspective, the share of innovations generated by firms in host countries has increased considerably.

capital is itself searching for promising investment opportunities *world-wide*.

Furthermore, the liberalisation of financial markets has encouraged *foreign direct investments* (FDI), which play an important role in the transformation process. Particularly during the 1990s, FDI flows have increased significantly, although their relevance varies from country to country. The nature of investment has changed recently, as mergers and acquisitions have become more important compared to green field investments (OECD 2000b). A major advantage of foreign direct investments is that they allow access to global knowledge. On the one hand, foreign affiliates can benefit from the local knowledge produced in their environment; on the other hand, they can also transfer knowledge from their home to their host country.

The other aim of the liberalisation process is to *facilitate and support trans-boarder trade*. International agreements on pulling down trade barriers aimed at stimulating economic growth and social welfare by expanding trade among countries. The expansion of international trade can directly be linked to processes of organisational and regional specialisation in the areas where they create comparative advantages. International trade can lead to substantial efficiency gains for producers as they experience a larger choice of cheaper and better quality products and services. *Services* have increasingly become the object of international trade, partly because the rapid diffusion of modern ICT has made the trans-boarder trade of intangibles much easier. Due to this new development, international trade now diffuses a broader range of innovation ideas, technologies and concepts (OECD 2000b).

ICT revolution

Modern ICTs and communication infrastructure determine the current state of technological innovation, and thereby contribute significantly to the development of the knowledge-based economy. Characteristic of modern ICTs is that they alter the conditions for the access, retrieval, processing, and communication of practically all types of information. Of particular importance is that these technologies make it easier to separate, trade, and transport information (Antonelli 2000).

Concerning the importance of modern ICT for innovation processes, we can distinguish between three aspects. Modern ICT significantly increase companies' capacity to *efficiently generate and process knowledge-based information* (Castells 2000). Such increased capacity may lead to a significant acceleration of innovation processes. Secondly, the fact that modern ICTs connect companies with core data banks means that *structured technological and scientific information become more easily available* to companies. Having access to such data banks means that companies can search more easily for complementary knowledge needed to develop product or process innovations. And modern ICTs also change *the communication* between firms; they allow intensive interaction and knowledge exchange between increasingly specialised companies in network structures. The fact that these dynamic

channels of information and communication are made available by modern ICTs may even contribute to further processes of specialisation.

One important aspect of modern ICTs is that they provide the material basis for *immediate global reach* (Castells 2000). Technological innovations of the 1990s, such as communication satellites, sophisticated antennas, digital subscriber line technologies, fibre optics, and other technologies, connect people and organisations *world-wide* and make rapid and extensive information exchange possible on a global scale. They act as the technical devise to allow globalisation to occur. Spatial and topical expansion of knowledge is countered with enlarged and accelerated mechanisms for its diffusion through modern ICT. Particularly the emergence of the Internet's key infrastructure applications, the WWW and the browser, has greatly expanded the potential of ICT. Through this technology, computers and communication systems are linked with each other in an *open network* that significantly increases their utility (OECD 1998a).

Modern ICTs, however, do not replace face-to-face communication in innovation processes; they can only support and intensify information and knowledge exchange. According to Daft and Lengel (1986), simple and stable communication environments tend to *favour* more formal communication mechanisms such as memos, faxes and e-mail. The informal *face-to-face communication* is characteristic of innovation processes where different types of cognitive frames and complementary knowledge must be combined to produce new insights (Bierly and Hämäläinen 1995).

Increasing complexity of science and technology

The process of *technological change has become increasingly complex and dynamic* opening up extended innovation opportunities. Various developments have contributed to this trend. *Scientific specialisation* has progressed rapidly during the last decades. Scientific disciplines have become more and more specialised in terms of topics and topography, resulting in an increasing 'division of scientific knowledge' (Pavitt 1998).

The growing specialisation of science has significantly contributed to the *acceleration of the speed and scope of scientific discovery*. Scientific knowledge is structured and produced in a fragmented way with little connection between disciplines and sub-disciplines, through a process of deepening and accumulation. While the scientific knowledge stock is growing faster than before, new scientific knowledge becomes more rapidly outdated than was the case in the past.

Berkhout et al. (1997) argue that innovation, in many cases, does not derive directly from science. Instead, knowledge required for innovation often differs quite significantly from scientific knowledge. Between scientific advance and innovative products and processes, knowledge is organised around *technology areas of a generic or multi-application nature* (OECD 1998a, 146). The process of

scientific diversification provides a growing number of technical[7] opportunities. The development of new technologies is an increasingly multidisciplinary effort. As a consequence, it is more and more difficult to separate technologies according to conventional disciplines (Meyer-Kramer 1997). On the contrary, new technologies more often incorporate *knowledge from various disciplines*. This means that technical progress is driven by the integration of separate knowledge elements.

Knowledge creation, however, takes place along *different lines of development*. There is no general trend that separates science from technology. In fact, *basic scientific research is increasingly nurturing innovation*; it has become the source of many innovations transforming economy and society. But it is mainly the high-tech industries that are closely linked to advances in basic science; here, the frontier between science and technology is increasingly blurred, as new discoveries may not only increase scientific knowledge but also lead to successfully commercialised innovation (OECD 1998a).

Knowledge creation, on the other hand, often advances through *technological practices running ahead of what science predicts* (Pavitt 2000b). Knowledge develops so rapidly that making a detour via the scientific system would be much too time-consuming (Willke 1998). This type of knowledge creation has been characterised by Constant (2000) as *recursive* involving "alternative phases of selection and of corroboration by use. [...] The result is strongly corroborated foundational knowledge: knowledge that is implicated in an immense number and variety of designs embodied in an ever larger population of devices, artefacts, and practices, that is used recursively to produce new knowledge" (ibid., 221). However, while a new technology often emerges with very little relevant scientific knowledge applied, its emergence can induce scientific research to better understand what has emerged and lay the foundation for subsequent development.

A large increase in technological opportunities arises from the birth of new generic technologies, such as electronics or genetic engineering. The diffusion of electronics and software technology in the electro-mechanical and mechanical engineering industries, for example, had a major impact on a whole set of products such as office machinery or machine tools, as it substantially altered their technology base (Ehrnberg and Jacobsson 1997). We can assume that biotechnology will have a similar broad impact on products in pharmaceutics, in agro-food and in wood industries.

The increasing complexity of knowledge creation and knowledge diffusion opens up *growing opportunities to develop new products and processes*. However, the relationship between basic research and the firm's capacity to use new knowledge is neither unidirectional nor straightforward. Pavitt (2000b) stresses that due to growing specialisation of scientific disciplines, companies are forced to deploy an increasing number of fields of knowledge to solve technical problems and to reach technical targets. New products and innovate concepts have become more complex and incorporate an increasing number of fields of knowledge; they

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[7] Technology should not be confused with closely related artefacts, as the former is used in a variety of different products.

have a wider variety of sources, which are often outside the direct control of companies.

As a result, companies that make the new products have at their disposal a broader variety of knowledge but they cannot cover all main disciplines. Not being able to produce all the needed knowledge internally, companies have to monitor other companies and knowledge producers across the world and also in different industries, as inter-disciplinary innovation becomes crucially important (OECD 2000b). Strategic networks often provide a more rapid access to the needed know-how since they can mobilise knowledge from various sources.

Changing demand patterns

Changing demand patterns have also opened up new opportunities for innovation. Due to increasing individualisation and quality consciousness, people are no longer satisfied with standardised products and services and they increasingly ask for individualised solutions for their problems. This has led to the continuous replacement of standardised mass products by *diversified quality products* (Streeck 1991). Innovation has become increasingly important for serving the diversifying demand and for improving quality. Moreover, the need to create demand and markets has become an important challenge to companies.

Traditional innovation theory takes demand and markets more or less for granted. In the case of the 'technology push model', it is at least implicitly assumed that there is a market for all innovations which will absorb the technological novelties. The 'demand pull model', on the other hand, argues that there will always be demand which fosters innovation activities, as the needs of human beings are practically unlimited (Kowol 1998).

Both approaches have been criticised for various reasons. The main argument is that *one cannot assume that demand and markets always exist apriori to stimulate or absorb innovations*. There is no doubt that in many cases innovating firms are able to develop technologies and services that address particular human needs. We can then assume that new products or services will diffuse rapidly. But often companies develop technologies without having a concrete idea of the relevant markets. We can talk about *technological solutions waiting for problems to occur* (Freyer 1963). People may then realise that new technologies or services can be applied to solve their problems or that these address particular needs. While in those cases a market does not exist apriori, it nevertheless emerges when the new technology is available.

In many cases, however, companies have to create demand and markets together with the development of new technologies. The Maslowian (1943) assumption that whenever a basic need is fulfilled, needs on the next, higher level will create new demand represents a very mechanistic concept and might only be true in the case of basic needs. At the highest levels of needs' fulfilment, where self-esteem and self-actualisation become important motivations for human beings, the

Maslowian model gives very little guidance for analysing demand patterns. People can satisfy these needs with very different activities like travelling, attending cultural events, learning new things, buying fashionable clothes, owning precious things, or talking to friends on the phone, and so forth. The terms 'experience economy' and 'dream society' reflect the growth of these new demand patterns (Pine and Gilmore 1999; Jensen 1999).

A vast variety of activities and goods can fullfil the need for self-esteem and self-actualisation; different people may have different priorities concerning particular activities and goods. Moreover, some people may not even have developed clear priorities; they may not even know what exactly they are looking for. Hence, we can imagine a variety of *latent demands somehow competing with each other*, not only at the collective but also at the individual level. It is a major challenge to firms' innovation activities to influence and change people's preferences for particular goods and services; for example, to make travelling more attractive for self-actualisation by combining it with specific cultural events.

The creation of new demand and markets for new products, processes or services has become an important part of innovation processes. It has to be closely integrated with the research and development as well as production and marketing activities of firms. Hence, advertising, design, and branding, which actively influence the *meaning creation of possible customers*, have become important activities in firms' innovation processes (Tuomi 2001).

Conclusion

New market challenges and new technological opportunities, we have argued, have contributed to the increasing role of innovation in industrial development. Here we have focused on the following factors: economic globalisation, deregulation and liberalisation of markets, ICT revolution, the increasing complexity of science and technology, and changing demand patterns. Those challenges and opportunities do not operate independently from each other; in fact, they are closely linked. Globalisation, for example, has been given a push by market liberalisation and deregulation. Giddens (1991) argues that economic globalisation would have been impossible without modern ICTs. The increasing specialisation and interdisciplinarity of knowledge creation processes is supported by the rapid diffusion of modern information technology and telecommunications infrastructure. And fierce global competition has increased the demand for new knowledge.

The above-mentioned challenges and opportunities and their dynamic interaction have caused increasing uncertainty and created what has been termed a *'turbulent environment'* (Emery and Trist 1965), making companies increasingly vulnerable. Companies need to prepare for *competing with what could emerge* out of such turbulent field. Because of these fundamental changes in their competition

environment, companies are forced to react with more complex strategies. On the one hand, they are *forced to specialise* and, on the other hand, they have *to enhance their innovation capacity*. Of course, both processes are very much intertwined.

Specialisation implies that companies concentrate on their *core competencies*. There are several factors that are forcing companies to specialise. The accelerating process of knowledge creation, for example, makes it more and more difficult for companies to participate in, or even follow, all the new developments in science and technology relevant for their innovation processes. Moreover, the broader the scope of products and services produced by a company, the bigger this challenge becomes. It is increasingly difficult for companies to maintain research and development as well as absorptive and transformative capacity in variety of different and unrelated fields of production.

The emergence of highly specialised global competitors makes the specialisation pressures even more intensive. In order to succeed in the global innovation competition, companies have to concentrate their resources and focus on those production activities and businesses in which they have a leading position while, at the same time, disposing of production where they are lagging behind and are less competitive than their more specialised competitors. Although there are no statistics available, the specialisation and complexity of value-adding systems are likely to be at their historical highs today (see e.g. Hodgson 1999; Hämäläinen 2001).

Innovation is seen by many scholars as the most promising strategy *to cope with uncertainty and to control areas of uncertainty* in their environment (Schienstock 1975). Innovation can be seen as a reaction of a company to unanticipated changes. If companies are capable to continuously produce innovation, it is less likely that they will be caught by unexpected technological, economic or social developments. And the more radical the innovation activities of a firm, the more likely it is that it will not be surprised by emerging technological trends or other major changes in its business environment.

The more specialised companies are highly dependent upon the *complementarity of other organisations*; hence, they hardly ever innovate in total isolation. The increasing dispersion of knowledge means that companies have to establish or strengthen their linkages with various actors, including customers, suppliers, universities, technology transfer institutions, and others. The changing competition environment implies that innovation becomes increasingly a collective undertaking.

This argument has strengthened the interest in the 'national innovation system' (NIS) approach among researchers as well as policy makers. The NIS concept focuses our attention to the problem of how to *co-ordinate and manage the processes of knowledge creation, acquisition, distribution, and use* in order to rapidly and continuously produce innovation. While innovation can be seen as a basic characteristic of market systems in general, the growing popularity of the concept reflects the fact that *systemic innovation* is a major contributing factor to industrial dynamics (Hauknes 2000; Galli and Teubal 1998). Systemic innovation

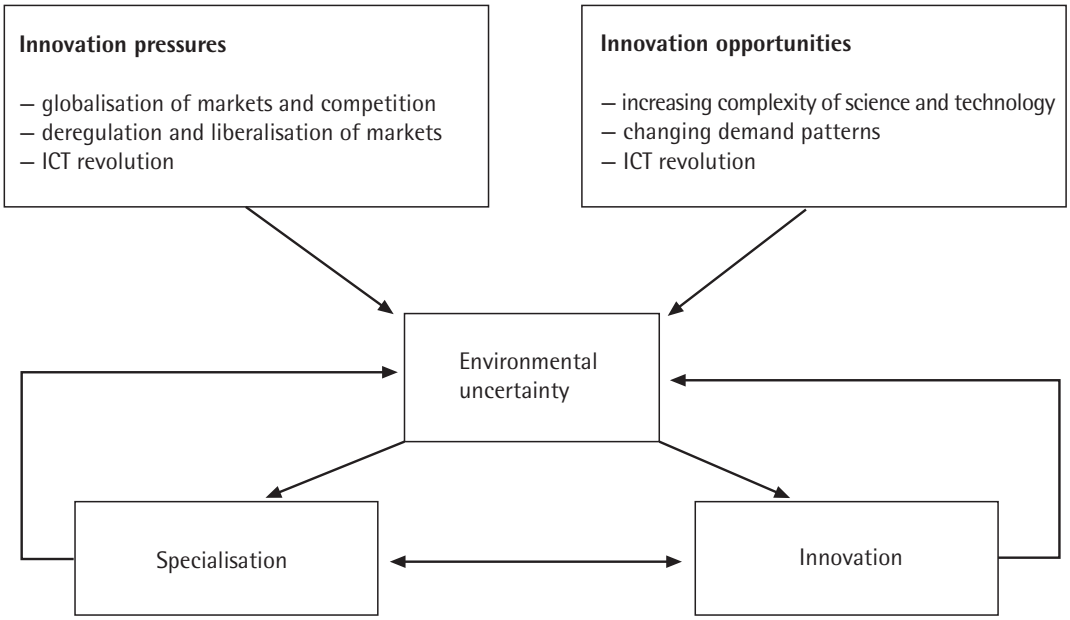

Figure 1. Specialisation and innovation in an uncertain environment.

requires effective coordination of knowledge flows, the main concern of NIS approach. The concept of national innovation systems aims at *capturing this systemic and interdependent character of innovation and technical change* (Soete and Arundel 1993). We will deal with the concept in Chapter Five.

3 TRANSFORMATION OF THE FINNISH ECONOMY[8]

This chapter will provide a theory of catching up and forging ahead during major paradigm shifts in the world economy. We will analyse the structural transformation of the Finnish economy in the context of the present paradigm shift. Our benchmarking analysis will shed some new light on the dynamics of structural adjustment processes in industrialised countries and highlight some of the structural challenges of Finland as it tries to maintain its position as one of the most competitive economies and a leading knowledge society in the world.

Theory of catching up and forging ahead

The neo-classical growth theory suggests that, over time, poor countries will catch up with the wealthier ones because they can learn from the leading countries' production methods and technologies. However, recent empirical evidence has supported this catching-up effect only among the relatively wealthy countries, really poor developing countries have been falling further behind (Barro and Sala-I-Martin 1995). Moreover, in recent years, even the *differences among industrialised countries have tended to increase.* In particular, the leading country of the new paradigm, the United States, seems to have been leaving others behind. This suggests that the catching-up phenomenon may be related to a particular phase in long socio-economic cycles. Hence, there seems to be a need for a more sophisticated theory of catching up and forging ahead for techno-economic paradigm shifts.

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[8] Parts of this chapter were presented by T. Hämäläinen in 'Das neue Millenium -Zeit für ein neues ökonomisches Paradigma?' 28. Volkwirtschaftliche Tagung, Austrian Central Bank, June 2000, Vienna.

Historically, the catching-up phenomenon has been related to the *mature stages of a techno-economic paradigm* (late 19th century and the post-Second-World-War period). At this stage, both the advance of the techno-economic frontier begins to slow down and the imitation of best practice becomes easier. The economic growth of the leading countries is slowed down by the fact that radical innovations become increasingly difficult to make along the established technological trajectories. These countries are the first to experience the growing problems of a mature paradigm (shortages of key resources, increasing organisational problems, changing patterns of demand, institutional rigidities, etc.). At the same time, the core production technologies and methods of the old paradigm become increasingly mature and standardised, and hence, easier to transfer across borders and to imitate. This is a *period of 'decreasing returns' in socio-economic development.*

Once the techno-economic paradigm shift really begins, the catching up process is further facilitated by the fact that the leading economies have heavy investments in the structures of the old paradigm (established infrastructure, production equipment, personal skills, core technologies, organisational arrangements and market structures). These 'sunk costs' may slow down the diffusion of the new paradigm because individuals and organisations are unwilling to 'cannibalise' their old assets by shifting to the new production paradigm. The resistance to change can also be increased by the leading societies' long success with the old socio-economic paradigm, which creates mental inertia and provides financial buffers against the accumulating problems of the old paradigm. As a result, these societies can easily become 'locked into' the old paradigm (see also Freeman 1995; Schienstock 1999). Only strong incentives for change, such as highly competitive markets or an economic crisis, can break such mental rigidities for structural change. The importance of economic crises for the improvement of socio-economic structures and economic competitiveness was particularly evident in the early 1990s, as we will show in the next section.

Hence, a techno-economic paradigm shift gives the more flexible catching-up economies a "window of opportunity" to pass by and forge ahead the old leading economies (Abramovitz 1995; Perez and Soete 1988). The most advanced catching-up economies naturally have the best chance of becoming the leaders of the new paradigm. Societies further behind the techno-economic frontier will have greater difficulties in catching up with the new paradigm.

During and after a major paradigm shift in the world economy, the competitiveness and growth of national economies depend upon their particular socio-economic *starting point* — their existing resources, technologies, organisational arrangements, product market structures, international business activities, institutions and government role — and their *adjustment capacity vis-a-vis* the emerging techno-economic and socio-institutional paradigms (Abramovitz 1995; Lipsey 1997). A good starting point (close to the new 'best practice' paradigm) and adjustment capacity give a society a clear advantage in socio-economic development due to the 'increasing returns' associated with the quick and balanced

adjustment to the new paradigm. The increasing returns to adjustment stem from the systemic interdependencies and positive feedback loops within the new techno-economic paradigm. More specifically, they come from the (Arthur 1994; Freeman 1995; Lipsey 1997):

(a) increasing specialisation and scale of production within the new paradigm;
(b) rapid learning of producers and consumers (about the new products, production methods and organisational arrangements);
(c) growing external benefits in production (emergence, growth and clustering of complementary industries and activities) and consumption (network externalities); and
(d) the external economic benefits of socio-institutional adjustment.

The societies that are unable to adjust in the early stages of the new paradigm, or can only adjust in an unbalanced way, will not gain the increasing returns of the new paradigm and begin to fall behind the leading countries.

In the early stages of the new paradigm, the increasing returns associated with the rapidly advancing techno-economic frontier make catching up very difficult for the late-adjusting societies. New resources, technologies and organisational innovations initially emerge in non-standardised forms and, hence, are difficult to transfer, especially across borders. As a consequence, the new leaders of the world economy tend to forge ahead the other advanced economies after major technological revolutions. For example, the United States increased its economic lead to the other industrialised countries in the early part of the 20th century, just as Great Britain had done in the early 19th century (Freeman 1995). As we have noted above, the same phenomenon seems to take place also in the current paradigm shift. In the next section, we will illustrate our theory with the recent transformation and growth experience of Finland.

Post-war growth experience in Finland: catching up and forging ahead

The post-war growth experience of Finland resembles the contemporary growth miracles of Japan and West Germany. After the lost war and large war reparations, the Finnish economy industrialised very rapidly on the back of heavy investments in export-oriented heavy industries such as paper and pulp, basic metals and chemicals. There was a national consensus on the investment-driven growth strategy, which rapidly brought Finland closer to the world's technological frontier and created new domestic technological capabilities (Pohjola 1996). The acquisition of foreign machinery and equipment played a key role in the technological catching-up process. Equally important was the determination with which the national education system was developed. The growth strategy was also supported by

tightly regulated capital markets (low interest rates), generous tax exemptions for investments, flexible exchange rate policies and the highly profitable barter trade with the Soviet Union. The Finnish welfare state was modelled according to the successful Swedish example.

At the end of the 1980s, Finland had reached the league of the wealthiest countries in the world as measured by the GDP per capita. The country's catching-up process was perhaps even more impressive than those of West Germany and Japan as Finland was *not* an industrialised economy before the war like these two other countries. However, at the same time, the structural inefficiencies and distortions created by the investment-driven growth strategy also began to emerge. The deregulation of financial markets (increasing real interest rates) and the collapse of the Soviet Union revealed the structural inefficiency of the Finnish economy. The fact that Finland was the most expensive OECD country both in 1989 and 1990 in PPP comparisons reflected this inefficiency.

Table 1 shows how the overall structural competitiveness rank of Finland deteriorated from the 9th place to the 14th place among the OECD countries between the early 1980s and early 1990s. The *overall competitiveness index* is an average of seven competitiveness factors in the new economic paradigm. These factors were synthesised from the vast competitiveness and growth literature in economics, strategy, management and innovation (see Hämäläinen 2001).

1. new productive resources (venture capital, human capital, scientific knowledge, ICT infrastructure;
2. new technologies (R&D inputs, innovations, adoption of ICTs);
3. new organisational arrangements (allocative, technical, coordination and dynamic efficiencies);
4. new product market characteristics (sophistication of demand, product market institutions, user-producer cooperation);
5. degree of economic internationalisation (foreign direct investment, international trade, cross-border alliances);
6. institutional incentives (taxation, regulation, returns to education); and
7. role of government (expenditures on efficiency and competitiveness vs. equity related tasks).

In the autumn 1990, the Finnish economy collapsed to the most severe depression in independent Finland's history. Numerous firms filed for bankruptcy, thousands of over-borrowed households defaulted on their debts and the banking system went into deep crisis. The unemployment rate topped at 20 percent and the state ran a massive budget deficit. Very soon, the state finances were at the mercy of international lenders. The crisis was too deep to be wiped under the carpet; *ad-hoc* explanations would not anymore return people's trust in the old institutions and ways of doing things.[9] It became clear the Finnish economy and society required major structural changes.

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[9] In psychological terms, the crisis created widely shared 'cognitive dissonance' or mental distress among Finnish people (Festinger 1957; Hämäläinen 1999). This unpleasant feeling of uncertainty was related to the growing mismatch between the old mental frames, values and norms of people and their new experiences in the rapidly changing techno-economic environment.

Table 1. The structural competitiveness of nations in the new techno-economic paradigm.

Early-1980s		Late-1980s		Early-1990s		Mid-1990s		Late-1990s	
Canada	0,62	USA	1,27	Japan	0,82	Sweden	0,85	USA	1,10
Switzerland	0,46	Switzerland	1,19	USA	0,69	Finland	0,71	Finland	0,88
Australia	0,43	Japan	0,70	Sweden	0,47	USA	0,62	Switzerland	0,72
USA	0,42	Germany	0,65	Netherlands	0,45	Canada	0,59	Canada	0,55
Sweden	0,41	Great-Britain	0,62	Canada	0,42	Switzerland	0,56	Netherlands	0,55
Japan	0,23	Sweden	0,60	Switzerland	0,38	Great-Britain	0,50	Denmark	0,42
Germany	0,20	Canada	0,52	Denmark	0,34	Japan	0,44	Australia	0,41
Netherlands	0,18	Netherlands	0,52	Germany	0,29	Norway	0,41	Sweden	0,36
Finland	0,15	Belgium	0,14	Great-Britain	0,27	Denmark	0,34	Ireland	0,28
Great-Britain	0,11	Australia	0,08	New Zealand	0,20	Netherlands	0,32	Norway	0,24
New Zealand	0,10	France	0,01	Belgium	0,16	Australia	0,22	Japan	0,23
France	0,01	Finland	-0,02	Australia	-0,04	New Zealand	0,21	Great-Britain	0,22
Norway	0,01	Denmark	-0,06	Norway	-0,05	Germany	0,10	Belgium	0,11
Austria	-0,01	Austria	-0,12	Finland	-0,08	France	0,01	Germany	0,06
Denmark	-0,02	New Zealand	-0,17	Austria	-0,12	Belgium	-0,02	New Zealand	-0,09
Belgium	-0,06	Norway	-0,24	France	-0,13	Ireland	-0,04	Austria	-0,28
Greece	-0,27	Ireland	-0,30	Ireland	-0,18	Austria	-0,09	France	-0,38
Irland	-0,27	Portugal	-0,79	Portugal	-0,63	Portugal	-0,75	Portugal	-0,46
Spain	-0,38	Italy	-0,80	Turkey	-0,63	Spain	-0,83	Spain	-0,62
Portugal	-0,62	Spain	-1,00	Greece	-0,66	Italy	-1,06	Turkey	-1,33
Italy	-0,63	Greece	-1,18	Spain	-0,90	Greece	-1,47	Italy	-1,34
Turkey	-1,05	Turkey	-1,60	Italy	-1,10	Turkey	-1,62	Greece	-1,64

In the early 1990s, Finnish firms laid off their workers *en masse*, reorganized their business processes, and considerably improved their productivity and competitiveness, and all this nearly without new investments. The government made drastic cuts in public expenditures, which had not been possible in better economic times. At the same time, the export competitiveness of Finnish firms was re-emphasised as a key policy goal. Also, individual citizens changed their behavioural patterns: people began to pay back their debts, worked harder and many sought new training opportunities to upgrade their skills.

As we can see, the economic crisis came with a silver lining: it reduced the society's mental rigidities to adjustment. Moreover, being a late-industrialising country, Finland had not become so deeply embedded in the old techno-economic paradigm as many older industrialised countries. Thus, the Finnish society has been quite flexible in its adjustment to the new techno-economic environment.

The positive impact of economic crises on structural adjustment capacity is confirmed by the data from other OECD countries in the early 1990s, the time of the previous recession in the world economy. Table 2 ranks the OECD countries according to their average economic growth rates between 1991 and 1993.[10] Finland, Sweden and Switzerland were the worst performing countries during those years but eleven OECD countries had an average economic growth rate below one percent during that period. The negative correlation between economic growth and the lagged structural upgrading was strongest among the worst performing countries but even the sample of all OECD countries shows a clear correlation between the depth of economic recession and structural adjustment in the following years. [11]

On the other hand, there was very little correlation between the economic growth rates and structural adjustment in countries with growth rates over one percent. Thus it appeared that only a relatively severe economic slowdown would reduce the mental rigidities of decision-makers to structural change. This may explain, for example, why the long but relatively mild recession of Japan during the 1990s did not lead to major structural reforms.

In Finland, a consensus on the new growth strategy began to emerge somewhere in the early 1990s once the government and industry began to emphasise technology and innovation as the basis of economic growth in the future (MTI 1993). In the mid-1990s, this technology- and innovation-oriented growth strategy was complemented by an emphasis on the new efficiency- and competitiveness-oriented role of the government (MTI 1996). With the severe economic crisis in

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[10] The change in the competitiveness rank is calculated as the difference between the overall competitiveness rank in the mid-1990s and early 1990s (see Table 1).

[11] However, as our calculations for the whole 1990s showed, the positive impact of economic crisis on structural adjustment tends to decrease after a few years. Thus long economic booms create a special challenge for maintaining the momentum of the structural adjustment process.

	Average growth 1991—1993	Change in competitiveness Rank: Early to mid-90s
Australia	1,8	1
Austria	1,8	-2
Belgium	0,7	-4
Canada	0,4	1
Denmark	0,6	-2
Finland	-3,6	12
France	0,5	2
Germany	4,8	-5
Greece	0,7	-1
Ireland	2,7	1
Italy	0,4	2
Japan	1,5	-6
Netherlands	1,7	-6
New Zealand	1,0	-2
Norway	3,2	5
Portugal	1,2	0
Spain	0,8	2
Sweden	-1,6	2
Switzerland	-0,5	1
Turkey	5,0	-3
UK	0,3	3
USA	1,7	-1

Correlation (5 worst performing countries)	-0,84
Correlation (10 worst performing countries)	-0,85
Correlation (all OECD countries)	-0,59
Correlation (countries with growth over 1 %)	-0,04
Correlation (countries with growth between 1 and 2 %)	0,02

Table 2. Depth of economic crisis in 1991—1993 and changes in the structural competitiveness rank of OECD countries between the early and mid-1990s.

the background, such a strategy was easy to understand. The Finnish economy was increasingly exposed to foreign competition and could not compete without world-class innovatory capacity, efficiency, and value-adding capacity. Having a strong engineering orientation, the Finnish value-adding strategy was primarily based on technological innovation. Policy makers wanted Finland to become a true knowledge-based society and the initial success of the telecommunications cluster provided support for this strategy. As a result, the role of technology policy

became central in the new growth strategy.[12] Perhaps as a reflection of the old input-driven strategy, increasing national R&D inputs became the central goal of technology policy in the late 1990s.

The increasing returns of systemic adjustment were reflected in the high multifactor productivity growth rate of Finland during the 1990s. According to OECD calculations, this rate, as adjusted for changes in the quality of human capital, jumped in Finland from 2.2 percent in the 1980s to 2.8 percent between 1990 and 1996. The corresponding figures for the US were 0.8 and 0.9, for Germany 1.6 and 2.0, and for France 1.9 and 0.5. The rapid systemic adjustment, increasing overall competitiveness and high MFP growth of the Finnish socio-economic system supported strong economic growth in the late 1990s.

Structural adjustment and national competitiveness in the late 1990s

The United States economy was the strong performer of the late 1990s. The rapid diffusion of the new ICTs and the acceleration of the US productivity growth towards the end of the 1990s led to a growing debate about nature and existence of the "New Economy" which could combine low inflation with high growth rates. Moreover, the surge in the US competitiveness was not limited to the production and use of ICTs. Measured by our broad overall competitiveness index, the United States was the most competitive nation in the late 1990s (see Table 1). Even without a major economic crisis, the declining competitiveness of American industry in the late 1980s (Dertouzos, Lester and Solow 1989; Womack, Jones and Roos 1991), brief economic recession at the beginning of the 1990s, and the highly competitive US markets and polity seem to have provided sufficient incentives for American firms and policy makers to continuously upgrade the structural competitiveness of their nation.

Finland was the second most competitive country after the United States at the end of the 1990s. Hence, Finland was able to maintain the second position that it reached in the mid-1990s. During the same period, Switzerland improved its competitiveness rank from 5th to 3rd position, Denmark from 9th to 6th position, the Netherlands from 10th to 5th position and Australia from 11th to 6th position. At the same time, Sweden dropped all the way from the leading position in the mid-1990s to the 8th place in the late 1990s. Other losers were the Great Britain from the 6th place to the 12th, Japan from the 7th position to the 11th, Norway from the

[12] The Finnish government had gradually increased the importance of technological competitiveness and technology policy already in the 1980s but it became *the core* the government's growth strategy only after the economic crisis of the early 1990s.

Table 3. Overall competitiveness of economic systems in the late 1990s.

	Standardised competitiveness factors:								Competitiveness	
Country	Resources	Technology	Organisat.	Prod. mkt	IBAs	Institut's	Governm.	Overall (average)	Ranking: Late 1990s	
Australia	0,83	0,28	0,44	0,41	-0,62	0,39	1,15	0,41	USA	1,10
Austria	-0,98	-0,26	-0,16	-0,08	-0,12	0,30	-0,67	-0,28	**Finland**	**0,88**
Belgium	-0,13	-0,29	0,10	-0,18	1,90	-0,37	-0,24	0,11	Switzerland	0,72
Canada	1,59	-0,18	0,59	0,47	0,05	0,55	0,76	0,55	Canada	0,55
Denmark	0,66	0,54	1,12	0,51	-0,18	-0,65	0,96	0,42	Netherlands	0,55
Finland	**1,49**	**1,53**	**0,77**	**0,93**	**0,26**	**0,46**	**0,74**	**0,88**	Denmark	0,42
France	-0,39	0,00	-0,80	-0,15	-0,65	-0,49	-0,18	-0,38	Australia	0,41
Germany	-0,44	0,31	0,17	0,53	-0,63	0,90	-0,40	0,06	Sweden	0,36
Greece	-0,87	-1,51	-1,93	-1,72	-1,21	-1,42	-2,80	-1,64	Ireland	0,28
Ireland	-0,54	-0,62	-0,55	-0,03	1,83	1,25	0,63	0,28	Norway	0,24
Italy	-1,08	-0,86	-2,22	-1,07	-1,00	-2,20	-0,97	-1,34	Japan	0,23
Japan	-0,34	1,85	0,13	1,12	-1,34	0,51	-0,29	0,23	United Kingdom	0,22
Netherlands	0,32	0,34	1,07	0,62	1,42	-0,53	0,56	0,55	Belgium	0,11
New Zealand	0,17	-0,39	0,64	-0,13	0,27	-0,06	-1,12	-0,09	Germany	0,06
Norway	0,88	0,63	-0,19	0,10	-0,33	-0,70	1,33	0,24	New Zealand	-0,09
Portugal	-1,31	-1,25	-1,30	-1,82	2,05	-0,17	0,58	-0,46	Austria	-0,28
Spain	-0,68	-1,20	-1,10	-1,04	-0,41	0,02	0,08	-0,62	France	-0,38
Sweden	0,92	1,70	0,68	0,57	0,53	-1,36	-0,54	0,36	Portugal	-0,46
Switzerland	0,49	0,66	0,68	1,41	0,07	1,35	0,38	0,72	Spain	-0,62
Turkey	-2,29	-1,84	-0,45	-2,10	-0,64	-0,83	-1,15	-1,33	Turkey	-1,33
United Kingdom	0,30	-0,32	0,60	0,16	-0,17	1,23	-0,28	0,22	Italy	-1,34
USA	1,40	0,87	1,71	1,50	-1,08	1,81	1,46	1,10	Greece	-1,64
Rank of Finland:	**2.**	**2.**	**4.**	**4.**	**7.**	**8.**	**9.**	**2.**		

8th to the 10th, New Zealand from the 12th to the 15th and France from the 14th to the 17th place.

Seven factors of competitiveness. Table 3 breaks down the overall competitiveness index into its seven component indices. These sub-indices reveal the competitiveness of each country's (a) productive resources, (b) technologies, (c) organisational arrangements, (d) product markets, (e) international business activities, (f) institutional framework and (g) government in the new techno-economic paradigm. For each country, the table also suggests more competitive countries that could be benchmarked for policy learning.

The seven tables in the Appendix provide a closer look at the numerous indicators from which the seven sub-indices are built. These indicators were selected to represent the emerging new paradigm of the world economy. Thus many traditional competitiveness factors — such as physical investments, wage levels and energy prices — were omitted because they do not yield sustainable bases for competitive advantage in the new environment (Hämäläinen 2001).[13] A closer look at the indicators reveals more specific policy challenges for Finland and the other OECD countries.

In the late 1990s, Finland was particularly competitive in terms of its productive resources (2nd) and technology (3rd). Canada was the most competitive country in productive resources; Japan and Sweden took the first two positions in technological competitiveness. Finland ranked fourth both in terms of new organisational arrangements and the nature of its product markets. In the organisational area, the USA, Denmark and the Netherlands are the countries to watch; in the product markets, the USA, Switzerland and Japan provide the best benchmarks for further development.

The international business activities (7th), institutions (8th) and government role (6th) provide more competitiveness challenges for Finland. Particularly, the institutional and policy-related innovations require more attention in order to guarantee the balanced upgrading of the Finnish socio-economic system.

Productive resources. The new techno-economic paradigm requires risky investments in new technologies and business areas. This has emphasised the importance of the availability of equity capital for new business ventures. Broad and well-functioning secondary markets are an important part of a highly developed venture capital sector. The availability of venture capital improved considerably in Finland during the latter part of the 1990s but there were still many countries with more listed companies per capita at the end of the decade. However, the secondary markets in Finland are likely to improve over time as the recent growth in first-round investments is reflected in more initial public offerings in the future.

The new economic paradigm puts a premium on created, advanced, specialised and intangible resources, particularly knowledge (Porter 1990; Dunning 1992;

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[13] This does not mean that these more traditional factors are not important for competitiveness, their competitiveness is a necessary, but not sufficient, basis for sustainable overall competitiveness.

OECD 1996a). High levels of education and scientific knowledge are increasingly important determinants of national competitiveness. In the area of infrastructure, the new ICT paradigm has created new demands: high-capacity information networks, wide access to the Internet, and competitive markets for service providers.

The Finnish higher education and research systems were very competitive at the end of 1990s, as was the ICT infrastructure. The slight weakness of Finland in main telephone lines per capita may reflect the substitution of mobile phones for fixed lines in increasing number of households and the other options in linking computers to the Internet (ISDL, ASD, cable TV, etc.).

Technology. There are two main elements in national technological competitiveness: the nation's ability to produce new technological innovations and the extent to which new technologies diffuse and are used in the society. We have chosen both input and output indicators for benchmarking the technological innovativeness of nations. The diffusion and use of the new ICTs, in turn, is critical for the productivity and growth in the new paradigm.

In the late 1990s, Finland ranked very high in terms of national R&D investments (2nd) and personnel (4th) among the OECD countries. Also, the innovativeness of the Finnish economy, as measured by two patent indicators, was high by international standards (4th). In the diffusion and use of the new ICTs, Finland was one of the leading countries in the world (1st-3rd).

Organisational arrangements. Productive resources will only yield economic benefits if applied efficiently and productively. The rapid structural change and intensive competition require both efficient reallocation of resources (allocative efficiency) and their efficient use by organisations (technical efficiency). Moreover, the increasingly specialised and complex production processes emphasise the need for efficient coordination (coordination efficiency). Finally, the new networked organisational paradigm requires increasing flexibility and adjustment of organisational structures (dynamic efficiency).

At the end of the 1990s, Finland ranked fourth in organisational competitiveness but a closer look at the different indicators reveals a very uneven performance. Particularly, human resources were not very efficiently used. A relatively high unemployment rate (17th) and short annual working hours (15th) represented low allocative efficiency from an organisational point of view. On the other hand, the female participation rate in the labour force was the highest in the OECD countries. Also, the technical efficiency of the Finnish economy left some room for improvement: although worker motivation (6th) and organisational incentives (4th) seemed to be rather good, competition in local markets did not seem to reach international levels (19th). Despite improved competition policies, the small domestic markets, long tradition of barriers to competition and the strong role of government in many services markets still pose a serious challenge to economic efficiency.

The geographical concentration of economic activities forms the spatial dimension of the new techno-economic paradigm. Geographical proximity to related firms and large labour markets brings clear benefits to the innovation and coordination processes of firms (Hämäläinen 2001). Despite the rapid concentration

of economic activities in recent years, Finland still lagged behind the old industrial countries in terms of urbanisation (17th) in the late 1990s. On the other hand, survey data indicate that Finnish firms were relatively competitive in process management (4th) and coordination efficiency. Finnish firms had also rapidly adjusted to the new organisational paradigm (1st–3rd).

Product markets. The nature of local product markets is an often neglected but important determinant of competitiveness. The sophistication of domestic buyers shapes the innovative incentives of local firms (Porter 1990). The differentiation of local product markets sets the initial and often most important context for firms' product development activities. Close cooperation between users and producers of new technologies and products improves the effectiveness of innovation processes (Lundvall 1985). On the other hand, high taxes on goods and services and an overly stringent product liability regime tend to reduce the dynamism and innovativeness of national product markets.

The competitiveness of Finnish product markets was not very good in the late 1990s as measured by the level of final consumption per capita (15th). However, according to a competitiveness survey, the sophistication of customers was considered to be above average (8th) and the advertising expenditure was the third highest per capita among the OECD countries. National differences in GDP per capita and the high level of product market taxation (18th) may explain part of the low consumption expenditure in Finland. On the other hand, in the survey, the technological cooperation among companies and the product liability regime in Finland were ranked the best among the OECD countries.

International business activities. In the global economy, national economic systems cannot remain competitive without deep integration with other national economies. The nature of integration has changed in recent decades: foreign direct investments (FDIs), intra-industry and intra-firm trade as well as cross-border alliances have replaced traditional international trade based on national comparative advantages as the most important forms of international integration (Dunning 1993).

The Finnish economy has rapidly become more international during the past decade. Particularly, the increased international mergers and acquisitions activity raised the FDI flows in the late 1990s (2nd). However, the inward FDI stock of Finland was still rather low in international comparisons (15th). Since foreign firms tend to improve competitive rivalry in local markets and bring new innovations to the economy, the attractiveness of Finland as a target for foreign direct investments should receive particular attention in Finnish policy making. The low levels of inward FDI, small domestic markets and the innovativeness of Finnish firms were also be reflected in the relatively low ratio of non-resident per resident patent applications. In terms of international trade, the Finnish economy has become increasingly open to foreign influences in recent years (10th) but still lags behind many other small countries such as Sweden, Netherlands, Switzerland, Austria, Belgium and Portugal.

Institutional framework. The national tax and regulatory systems set the context and incentives for firm and individual behaviour. The institutional framework has an important influence on the national resource creation, innovation and organisational processes and, hence, on the development and sustainability national competitiveness.

High levels of taxation tend to reduce economic incentives and hence competitiveness. The Finnish tax system did not provide good economic incentives for work and entrepreneurship: in the late 1990s, the general tax level (20th), income taxes (20th) and corporate taxes (19th) were among the highest in the OECD. On the other hand, survey evidence suggests that the regulatory framework was very competitive in Finland (1st–4th), only the flexibility of the Finnish labour markets leaved some room for improvement (8th). The educational incentives were also relatively competitive in Finland: the impact of education on employment prospects and earnings was ranked seventh and second in the late 1990s, respectively.

Government role. The systemic transformation and increasing global competition have also challenged the traditional role of government in national economies. Particularly, the balance between the equity-oriented tasks of governments, on the one hand, and their efficiency- and competitiveness-oriented duties on the other need to be re-evaluated in the changed techno-economic context. In the more competitive environment, more emphasis needs to be put on those government activities which directly support economic efficiency, competitiveness, and growth and hence create a sustainable basis for the social equity-oriented government expenditures. For example, education, research, and infrastructure belong to this group of government activities. They are typically motivated by some kind of market or systemic failure, which makes pure market solutions inefficient. Without an efficient and competitive economy, the social equity-oriented expenditures of government are on a fragile basis.

The Finnish government became increasingly competitive during the 1990s. The social expenditures were still above the OECD average (10th), but in terms of income transfers (8th), public education expenditure (6th), and particularly public R&D expenditure (1st) the Finnish government was more competitive. The only concern with the Finnish government related to its internal organisational adjustment. According to international experts, the structures and practices of the Finnish State do not match the needs of the new socio-economic environment (Bouckaert, Ormond and Peters 2000; Castells and Himanen 2001). For example, the Finnish government lagged way behind the international frontier in the utilisation of the Internet (19th) in the late 1990s as measured by an e-Government index. At the same time, the coordination of interdependent activities had become a major challenge for Finnish policy makers (Bouckaert, Ormond and Peters 2000).

Coordination mechanisms in Finnish innovation policy

As the Finnish transformation process into knowledge economy can be seen as a collective undertaking, it is important to understand the *dominant coordination mechanisms in the innovation system*. Here we suggest the *establishment of a shared systemic vision and discursive coordination* as the two key elements of coordinating the various actors in the process.

Economic restructuring does not take place automatically as a reaction to an economic crisis; instead, it is always influenced by a systemic vision (Chang and Rowthorn 1995) or the Leitbild[14] of restructuring. A systemic vision can be characterised as a set of general ideas of how to create economic growth, develop economic structures efficiently, and to restructure production processes. It also has a normative dimension, as it becomes the basis of practical restructuring processes. A major advantage of a systemic vision is that it makes communication among social actors possible, even if they have different interests and preferences. During the 1990s, the 'knowledge society' became the new systemic vision in Finland which guided the various actors in the restructuring process.

The second aspect of successful coordination and transformation management is social discourse among the various interdependent actors of the system. In discursive coordination, economic activities are coordinated through continuous and rich communication and mutual adjustment.[15] *Systemic discourse* can be viewed as a platform to jointly create and exchange information among economic actors. Discursive coordination is not primarily intended to create consensus among the participants but it aims to *initiate learning processes*.

With respect to discursive coordination, the *key role of the Science and Technology Policy Council of Finland* as the highest S&T policy body in the country has to be mentioned. It is chaired by the Prime Minister, and has a membership consisting of several ministers, S&T policy representatives, business people, representatives of major research centres, and the employers' and employees' organisations. The main guidelines of the Finnish S&T policy are developed in this body. The composition of this high-level coordination structure guarantees that scientific progress and technological development are viewed from the perspectives of different economic actors. The long-standing existence of this institution can also be seen as crucial in integrating and overcoming fruitless struggling and 'territorial thinking' among ministries. Every three years, the Council draws up an influential science and technology review, which outlines general visions and strategies of Finnish S&T policy. The Council has played a key role in the creation of a new economic development path by launching the new systemic vision of a

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[14] A Leitbild is defined as a symbolic scheme for creating reality (Berger and Luckmann 1967).

[15] As we will see in Chapter Eight, this is also a typical coordination mechanism in inter-firm networks.

knowledge society.

The mechanism of discursive coordination obviously works quite well in the design of technology and innovation policy through the Science and Technology Policy Council of Finland. There seem to be some problems, however, as far as the coherent and concurrent interpretation and implementation of the vision are concerned. The vision-oriented policy gives ministries space for different interpretations. While this may increase the acceptance of the vision, it also makes *high demands on the coordination of independent programmes and activities* among ministries. In Finland, the horizontal interaction, cooperation and mutual adjustment of interdependent public sector organisations and departments is not always effective (Bouckaert, Ormond and Peters 2000; VTV 2001). Due to systemic transformation and the increasing interdependence of different policy fields, ministries need to pay more attention to mutual adjustment and coordination of their policy programmes at the implementation level.[16]

Conclusion

The recent success of the Finnish economy in general, and its telecommunications cluster in particular, has attracted a lot of foreign attention. However, there seem to be many different factors behind the success and no one can provide a comprehensive explanation. Based on the previous analysis, it looks as if small and culturally homogenous countries like Finland could have a competitive advantage in the systemic adjustment required by the transformation of the world economy. The increasing returns of the new paradigm can more easily be reached when the key decision makers in different fields can easily be gathered around one table and their previous social relationships and mutual trust facilitates the coordination of complementary policies (see also Lundvall 1999). Such systemic adjustment is likely to be more difficult in larger and culturally more diverse societies.

Maintaining the momentum of systemic upgrading is not easy in Finland. The memories of the crisis of the early 1990s are already fading away and the rapid economic growth of recent years is leading to increasing demands on government expenditures. In this environment, continuous structural upgrading demands increasing attention to the remaining and future structural challenges of the Finnish economy and society. Unfortunately, the Finnish economic policy discussion has traditionally been focused on macroeconomic issues such as interest rates, currency, state budget, inflation, and so forth (see Table 4). Such discussion does not help the structural adjustment process very much. Much more attention and

[16] The reasons for increasing coordination problems in the public sector are analysed more carefully in Chapter Ten.

analysis would be needed to structural competitiveness issues. These are typically microeconomic by nature.

Macroeconomic		Structural	
Interest rate	16 480	Research	14 014
Currency	11 263	Environment	8 047
Pay	8 756	Technology	7 365
Budget	8 046	Education	6 894
Unemployment	6 920	Energy	5 980
Prices	6 680	Knowledge	3 874
Investments	6 547	Internationalisation	1 401
Inflation	6 485	Infrastructure	1 253
Taxation	6 441	Innovation	745
Consumption	5 795	Social security	639
Economic growth	3 798	Regulation	598
EMU	3 204	Income transfers	308
Euro	2 594	Venture capital	291
Foreign trade	1 790	Incentives	265
Current account	1 383	Health care	241
Incomes policy	1 378	Cluster	231
		Networking	69
		Welfare services	63

Table 4: The frequency with which certain key words appeared in the leading Finnish business daily 1 January 1990 – 31 December 2000. (Source: Kauppalehti)

The structural and industrial policy debate in Finland has tended to focus on research, technology development and education. Our benchmarking analysis suggests that, in the future, more attention should be paid to *organisational, social and institutional innovations* in the following areas: public sector organisations, social security and tax systems, the appropriate division of labour between the government and the private and third sectors. The Finnish economic system cannot remain competitive in the future if these key framework conditions do not meet the international standards.

The interpretation of benchmarking results must be done very carefully. National economic systems have very different historical and cultural roots and they can

prosper with quite different versions of the new economic paradigm. Indeed, the two most competitive economies in the late 1990s, the USA and Finland, provide a good example of this. The special national characteristics also emphasise the importance of systemic interdependencies. Each nation should aim to create a synergistic socio-economic system where the different components of the system support and complement each other. This underlines the need for *horizontal coordination* among different government agencies and ministries as well as between the different levels of the government (local, regional, national and international). Equally important is close cooperation between public, private and third sector organisations in different fields.

The systemic and balanced adjustment of the society can be facilitated by the provision of information which helps policy makers to focus on the most urgent structural challenges (Brouckaert, Ormond and Peters 2000). Hence, structural competitiveness benchmarking should be made a continuous activity in Finland. Currently, no private or public institution produces such benchmarking studies on a regular basis. Due to system specificities, the existing foreign benchmarking studies do not provide ideal information for the Finnish policy-making purposes. Moreover, the benchmarking process is valuable in itself by committing the key policy makers to a shared view of the country's future challenges and by facilitating the horizontal coordination government activities.

Successful systemic transformation also requires active coordination by policy makers (Chang and Rowthorn 1995). We argued above that systemic transformation cannot be effectively facilitated by traditional hierarchical government structures: it requires a shared vision and discursive coordination. Visionary policy-planning and horizontal communication work well among the core policy makers in the Finnish innovation system in the Science and Technology Policy Council. However, the effective implementation of cross-sectoral innovation policies still poses considerable challenges. More generally, the Finnish government should develop its systemic coordination capabilities in the face of the increasing dynamism in its environment and the increasing interdependence and complexity of its activities.

4 INNOVATION AND LEARNING

The aim of this chapter is to foster a better understanding of the nature of modern innovation processes. We first take up the issue with the linear model of innovation, which to some extent still influences the thinking of policy makers. Here we reason that innovation is a complex, highly uncertain interactive process consisting of a variety of different activities. But we do not argue that the linear model has no empirical basis; it rather represents an exceptional mode of innovation, while the combinatory model and the circular model of innovation accentuate more common phenomena of innovation. We further emphasise the importance of social innovations; they are often difficult to copy and can therefore secure sustainable competitiveness.

The second part of the chapter deals with individual and organisational learning processes, as innovation processes do not only produce new products and process technologies but also enhance individual and organisational competencies. The concept of social practices suggests a more radical view on innovation. It assumes that technological novelties become innovations only when they start playing an important role in meaningful social practices. At the end of this chapter, we will demonstrate the usefulness of the 'community of practice' concept by referring to the open source development model.

The nature of the innovation process

From a transcendental to a mechanistic perspective of innovation

Early theories dealing with the aspect of knowledge creation conceded a central role in the innovation process to the 'heroic inventor', whom the proponents of the theories viewed as a force that produces new knowledge and reveals hidden laws of nature (Freeman and Perez 1988). In his early work, Schumpeter developed a similar *'big man theory'* (Schienstock 1975). Focusing on the aspect of knowledge application, he stressed the role of the 'heroic entrepreneur' in innovation processes. According to Schumpeter (1942), the entrepreneur, more than the inventor, becomes the creator of new things due to specific motives and characteristics like the willingness to take risks and to fight for success, the motive to exercise power, and the joy of creating something.[17] Innovation then depends upon *'objective, irrational moments'*, such as pure chance or *'subjective, individual-related moments'*, such as inspiration, sudden inside, or ingenuity. Under such conditions, the structure of the innovation process cannot be analysed from the outside; it is impossible to control and manipulate the innovation process according to the criterion of efficiency (Schienstock 1975).

Usher (1954) already criticised the *transcendental perspective* of the 'big man theory'. His *'mechanistic concept'* of innovation interprets innovation as a *collective labour process*, which no longer depends on exceptional personalities. This approach argues that the structure of the innovation process can be analysed from the outside and that it is possible to plan and organise innovation processes according to the criterion of efficiency. It is assumed that the innovation process in principle can be integrated into rationally structured systems of activities (Schienstock 1975). Consisting of a number of very different knowledge elements, it can only be carried out *through a complex division of labour* (Van de Ven et al. 1999, 35), which often goes beyond individual firms. There is no doubt that individuals and single firms play a crucial role in the development of specific innovations, but the process of knowledge creation and diffusion involves a complex web of interactions among a range of different organisations and institutions.

The linear model of innovation

Concepts relying on the contribution of extraordinary individuals to knowledge creation and knowledge use have paved the way for the so-called *linear model of*

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[17] Besides the entrepreneurial mode of innovation, referred to as 'Schumpeter mark I', he also described the 'routinised' (big firm) mode of innovation, referred to as 'Schumpeter mark II'.

innovation.[18] It mainly deals with *explicit knowledge* developed in research processes. In this model, basic research is placed at the beginning of a causal chain that ends in productivity growth, mediated by innovation and diffusion. Basic research produces theories and findings that are redefined in applied research, then tested in the development process, and after that marketed as industrial innovations and taken into use. Each level in the linear model produces outputs that are transferred to the next level as inputs. *The flow of knowledge is unidirectional,* that is, later stages do not provide inputs for earlier stages (Kline and Rosenberg 1986, 285). The model implies that the extent to which basic research is conducted substantially influences the opportunities for technological innovations, which in turn determine the economic growth rate. The main assumption of the linear model is that new knowledge will always find its way into marketable products without major transformation problems.

This traditional approach is not seen as realistic and several *critical remarks* have been made in the relevant literature (Kline and Rosenberg 1986; Lundvall 1992; Schienstock 1994; Jorde and Teece 1990; Dosi 1988; Cohen and Levinthal 1989). The following more or less *implicit assumptions* and other elements underlying the traditional approach can be criticised:

(1) innovation processes are seen as exceptional events;
(2) knowledge creation is understood as an isolated processes of reasoning and inference from the rest of human activities;
(3) problems of uncertainty are not dealt with;
(4) research focuses only on R&D as the main function in innovation processes; and
(5) collaborative elements are not seen as relevant.

There is now, as Freeman argues, increasing evidence that the linear model of innovation that assumes a causal link between new scientific knowledge and innovation represents an exception rather than a rule (1987). The central process of innovation is not science but design and redesign, which take place throughout the whole innovation process. New scientific knowledge will not automatically lead to an increase in innovation activities; it is also not necessary for innovation to occur. Innovation can be triggered by other causes: learning processes in production, new market demands, or new possibilities to apply existing knowledge in other contexts.

It is generally accepted that innovations cannot be characterised as marginal phenomena; instead, they must be understood as a *basic characteristic of markets*. As innovations are a natural mode of acquiring competitive advantages, they can take place at any time in all parts of the economy; understood in this way,

[18] We can also talk about the 'cascade model' (Schienstock 1994) or the 'serial model' (Jorde and Teece 1990).

innovation is a *ubiquitous phenomenon*.[19] If we use such a concept, there is no need to always associate innovations with radical technological changes only; *incremental changes* are also included in the concept of innovation (Rosenberg 1982).

Innovations do not occur as a limited number of giant mental leaps within the human mind, as the traditional mentalistic perspective on knowledge assumes. They are not limited to cognitive processes. Instead, knowledge creation is intertwined and co-evolves with practical activities (Hakkarainen et al. 2001). There is now widespread agreement that the process of knowledge creation cannot be separated from other human activities. We can characterise innovation as being *embedded in social activities*. Particularly concepts that rely on the idea of 'communities of practice' stress this aspect of social embeddedness. This also means that innovations have to be visible as changes in economic behaviour. Schumpeter has already defined innovation as "doing things differently" (1939), which emphasises the *activity-based conceptualisation of innovation*.

Multi-activity is another salient feature of innovation. This means that innovation is not a single event but a *process*. This, for example, is expressed in the following definition by Dosi: "In an essential sense, innovation concerns the search for, and the discovery, experimentation, development, imitation, and adoption of new products, new production processes and new organisational set-ups" (1988, 222). Of course, the innovation process does not unfold automatically. We have to emphasise the important role of active individuals or collectivities in carrying out different innovation activities.

Furthermore, innovation is an *ambiguous and uncertain process*. "It is", as Dosi (1988) argues, "an activity in which 'dry holes' and 'blind alleys' are the rule, not the exception". We can distinguish between *technical and commercial risks*. It is, for example, very difficult to identify the adequate procedures that will lead to a technical solution for an existing problem. We do not know which path may yield fruit unless plausible alternatives are explored (van de Ven et al. 1999). And whether an innovation will meet the often very rapidly changing market demand is also highly uncertain. *Coping with uncertainty* can be seen as an inherent characteristic of innovation processes (Schienstock 1975). Because of this uncertainty, we cannot identify clear sequences of stages in innovation processes; instead, we have to analyse innovation as a *recursive process*, in which particular innovation activities can become both cause and effect, consequence and prerequisite (Kowol 1998). Companies can start searching for a new technical solution, for example, because the successful commercialisation of earlier solutions was very uncertain.

Lundvall has characterised innovation as a *fundamentally social process* in nature (1992). The argument here is that innovation is a collective undertaking, which involves a number of different actors with different skills and competencies.

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[19] This is not in contradiction with the argument that specific innovations can only occur under specific circumstances and in a specific environment.

This means that the diversity of competencies for carrying out innovation processes successfully is as relevant as it is for creating new ideas.[20] Hauknes (2000), taking the firm as the nodal point in innovation processes, characterises innovation as a *multi-organisational phenomenon*. This is because companies' capability to innovate to a great extent depends on knowledge produced externally. Companies in general need complementary knowledge to be able to innovate. Therefore, cooperation with firms and other organisations is an important factor that shapes innovation processes. The concept of *systemic innovation* highlights interdependencies between a firm and other organisations.

The multi-organisational aspect is even more important, as *speed to market* becomes an increasing criterion of economic success. Under continuous time pressure both small and large companies reach out upstream and downstream, horizontally and laterally, to develop and assemble leading edge systems (Jorde and Teece 1990). Particularly for small companies, time competition may require accessing complementary assets, which lie outside the organisation.

Different modes of innovation

Scientific research, we can conclude, has an important but more limited role in the innovation process than the linear model assumes. It is rather exceptional that innovation processes develop according to the linear logic: most innovations are carried out using available knowledge, even though it might be scientific in nature. Such a *combinatory character of innovation* is noted quite often in the literature (Hamel 1999; Kogut and Zander 1997). Innovation capability is seen more in terms of the ability to exploit systematically the effects produced by new combinations of existing knowledge and use of knowledge pieces in the existing stock of knowledge. The novelty of an innovation arises from the fact that existing knowledge from various scientific fields is put together and integrated in a new way. The various pieces of knowledge were not produced for developing this specific innovation; with respect to it, they represent 'unintended resources' (Tuomi 2001). If the existing knowledge does not allow problem solving, scientific research may become part of the innovation process.

While the 'combinatory approach' questions the importance of new knowledge for innovations to occur, the *'demand-pull theory'* refers to the dynamics of the market as the motor of technological change. According to this model, new demand will always occur stimulating respective innovation activities, whenever existing demand is satisfied. The market stimulates search processes for knowledge for those problems the solutions for which are expected to be highly profitable (Schmookler 1966).

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[20] In general, the aspect of diversity is mainly discussed with respect to the aspect of knowledge creation.

Such an approach is very appealing to social scientists in that it stresses the social shaping of technological progress but it also has some deficits (Kowol and Krohn 1995). The technological or science-push model does not explain, why some innovations are successful and others not and why many innovations fail and have not been accepted by the market. The market-pull model on the other hand, has the disadvantage that it is not possible to always attribute an innovation to specific demands. Actually, often demand has to be created first for specific innovation.[21] Furthermore, the 'demand-pull model' does not deal with the problem of technological uncertainty within innovation processes, since it assumes a technical solution to emerge whenever there is market demand. And finally, the problem of how to organise innovation processes is not touched upon. Somehow the demand-pull model also assumes some *kind of linearity*.

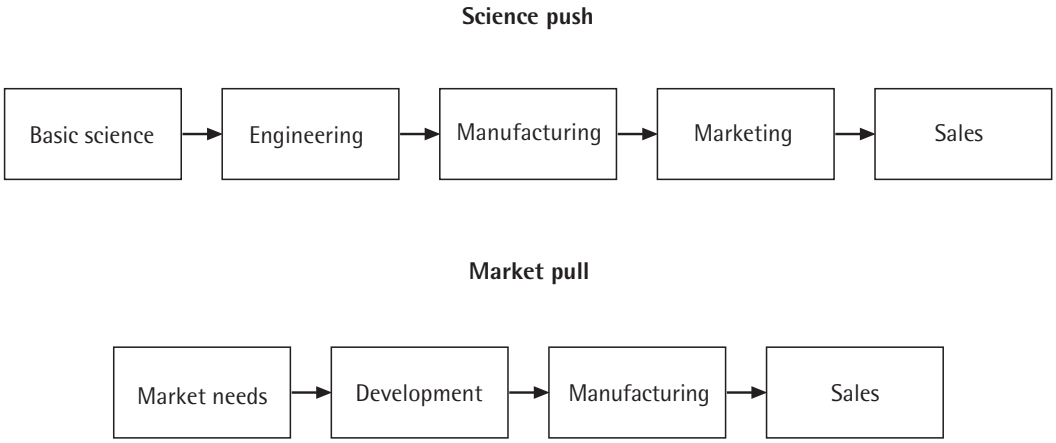

Figure 2. Traditional (linear) models of innovation. (Source: Arnold and Bell 2001.)

Innovations often occur in the course of *normal economic activities*. While producing things or providing services through experimental processes, users can develop their technology (Brousseau and Rallet 1998). Many theoretical and empirical studies have indicated the *active role of users* in the development of technology (Latour 1991; Sorensen and Levold 1992; von Hippel 1998). It has been stressed that it is very difficult to distinguish between an active design phase of technologies, on the one hand, and a passive phase of using technology on the other. Empirical findings, for example, demonstrate that the use of modern ICT and its integration into work processes is a very active process. Particularly the

[21] We have discussed this aspect to some extent in Chapter Two.

introduction of modern technology, but also its later use, very often includes modifications, and therefore, an element of *re-invention*.

The *'circular' or 'recursive model'* assumes that innovation can be triggered by various causes. Instead of conceiving of innovation as a linear process, we have to understand the creation of novelty as a recursive process. This means that we have to take into account complicated feedback mechanisms and interactive relationships involving science, technology, learning, production, and demand (Edquist 1997, 1).

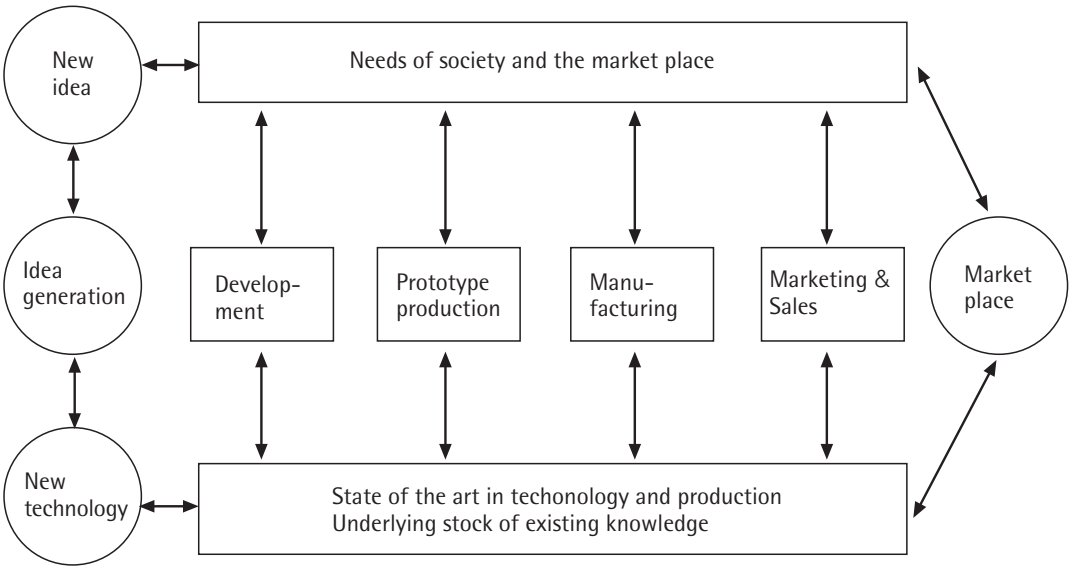

Figure 3. Modern coupling model of innovation. (Source: Arnold and Bell 2001.)

While explicit knowledge is in focus in the linear model, the circular or recursive model emphasises *tacit knowledge*. The circular model conceives of innovation as an *interactive process of a social nature*, emphasising cooperation, not competition (Lundvall and Johnson 1994). Much more than with the linear model the focus is on the connection among *company-internal, company-external, and technological factors* (OECD 1992). This is based on the assumption that innovation processes vary from company to company and that innovation to a great extent depends upon organisational learning processes enabled by human capital, organisation forms, and ICT use. As there is no clear development logic, an efficient *innovation and knowledge management* within and among firms becomes crucially important, especially now that time has become a major source of competitive advantage.

Here we propose not to understand the 'cascade model', 'the combinatory model', and 'the circular model' of innovation as three different analytical

perspectives or conflicting concepts of notions of interpreting innovation processes. Instead, we see them as different types of innovation processes that can be found in reality. *Radical or breakthrough innovations* imply the linear logic of the cascade model giving scientific research a key role, as the driving force is new knowledge. Even if these innovations are rare, they have far-reaching consequences, since they can become the basis for the development of entirely new industries. The combinatory model implies a more *routine use of a technological base* allowing innovation without the need for leaps in technology (Soete and Weel 1999, 10).[22] It is often market forces that stimulate combinatory innovations. Incremental innovations can be seen as a widespread phenomenon occurring through *cumulated experience and learning processes in production.*

Technical and social innovations

It is quite common to differentiate between *product innovations*, on the one hand, and *process innovations* on the other. Product innovations can be both new goods and new services. With respect to process innovations, we can differentiate between *technological and organisational innovations*. In practice, however, we can find close relationships between the different kinds of innovation. For example, the creation of a new product often requires the introduction of new process technologies. Furthermore, the introduction of new process technologies will hardly lead to higher productivity without concurrent organisational changes. And, with respect to modern ICTs, it becomes *more and more difficult to distinguish between new goods and new services.* Innovation processes, we can conclude, are often of a very complex nature, including various kinds of novelties.

Innovation research mainly deals with technical innovations, but the innovation concept is not restricted only to them. Schumpeter, one of the founding fathers of innovation research, already had a much broader concept, defining innovations as the doing of new things or as the doing of things that have already been done in a new way (1947). New production processes, new organisation forms, the opening of a new market, the development of new products as well as new ways of marketing products are perceived as innovations by Schumpeter (1947; see also Lundvall 1992).

There are good reasons for giving more attention to *organisational innovations*. First of all, new organisational forms, as Womack et al. (1991) have demonstrated, can become key sources of increased productivity and innovation activities, depending on whether or not they provide incentives for creating novelties. Furthermore, technical change and organisational restructuring are closely linked,

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[22] One can of course argue that science-based innovations are also always combinatory in that they combine new scientific knowledge with the existing capabilities of the firm.

they *co-evolve*, and in addition, technical innovations are shaped by social actors working in specific organisational arrangements (Edquist 1997). Finally, the more innovations become multi-organisational phenomena, the more they depend on new efficient forms of inter-organisational coordination.

Particularly when the fate of companies is more dependent on their capability to continuously produce innovations than on the success of one single fundamentally new product or process technology, organisational innovations are becoming crucially important. The knowledge incorporated in organisation forms and in human capital, social practices, business culture, and the like is of a tacit nature; therefore, it represents an asset which can hardly be copied and which guarantees *sustainable competitiveness*.

Nelson and Winter (1982) have stressed the importance of developing *routines for applying knowledge and continuously producing innovations*. According to their definition, routines in general represent regular and predictable behavioural patterns within firms that are coping with a complex environment and continuous change processes. The fact that innovations are characterised by great uncertainty does not preclude companies from developing well-defined routines for the support and direction of their innovative effort (Nelson and Winter 1982, 134). Organisational structures and practices must be seen as an important part of those routines that companies develop to be able to continuously produce new knowledge and innovations.

While the concept of innovation routines refers to companies' organisational practices, the concept of *social innovations*, which has lately attracted greater attention, is related to a wider context. Organisational innovations and new services are an important subgroup of social innovations. However, the concept covers a broad variety of different phenomena and is therefore very vague. The following definition seems to be rather useful: "Social innovations can be defined as new ways of reaching specific goals and they include new organisation forms, new regulations as well as new life styles that solve problems better than traditional practices do and that are worth imitating and/or institutionalising. Innovations have to change the direction of social development" (Zapf 1989).[23]

The term 'social innovation' refers to both processes of restructuring within the production sphere and the wider institutional framework (Gershuny and Miles 1985)[24]. *Regulatory innovations* are definitely an important part of social innovations.[25] For example, the open-source licensing policy can be seen as an important social innovation, as its main idea is to legally allow the improvement and adoption of software developed by others instead of guaranteeing a monopolist use for the 'inventor' (Stallmann 1999). But social innovations also include changes

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[23] This definition is still rather unspecific.

[24] Tuomi criticises the term social innovation, arguing that all innovations are social in that they have to be integrated into social practices (2001: 16)

[25] Stewart (1981) uses the term social innovation instead of regulatory innovation. This, however, restricts the content of social innovations.

in *individual lifestyles and cultural frames*. The following typology (Zapf 1989) gives an overview of the variety of social innovations with examples to illustrate them:

- organisational changes within and among companies (group work, lean production, inter-organisational networks, flexible working hours);
- new services (use of web pages in marketing);
- new social techniques (telework at home);
- self-created social innovations (participation in development projects);
- political innovations (social pact for growth and employment, interregional cooperation);
- new patterns of serving demands (self-service, telelearning);
- new lifestyles (new patterns of consumption, changes in the time budget); and
- new institutions (science parks).

These different types of social innovations are, of course, closely linked. New organisation forms cannot function effectively without changes in the attitudes and behaviour of people. But at the same time, changes in the institutional support structure are also needed to make new organisation forms function effectively. Continuous improvement and incremental innovations depend on the willingness of workers to improve their knowledge in a process of lifelong learning.

Some scholars differentiate between market and social innovations (Stewart 1981). Here social innovations include, among other things, the development and adoption of new products and processes that deliver improved *social performance* presumed by regulations, but firms cannot directly benefit from them through market sales. Social innovations could include the development of clean automobile engines, less polluting, safer industries, and environmentally superior control mechanisms, for example (Määttä 2001). Of course, a given innovation may confer both market and social benefits. But even if this is not the case, companies may benefit indirectly, as is the case in the field of environmental protection that may promote the green image of firms (Hilden et al. 2001). Although we do not agree with the above interpretation of social innovation, it nevertheless underlines the importance of innovations for *achieving sustainable development* (Meyer-Kramer 2001).

The service sector is the domain of social innovations. The standard classification of innovation as either a product or process innovation may actually lead to the fact that many service innovations are overlooked. Miles (1996) mentions *delivery innovation* as an exceptionally important feature of contemporary *service innovations*. Nearly all new business consultant activities can be characterised as social innovations. Many service innovations, however, also involve technical novelties, while on the other hand, technical innovations increasingly develop together with service innovations. Actually the *distinction between technical and service innovations* tends to blur the more modern ICTs penetrate products and production processes. This means that when analysing innovation processes, we have to focus on the *interrelationship between the technical and the social dimensions* of innovation processes.

Learning processes

We have so far concentrated on the creation of novelties within innovation processes. Now we will turn our attention to the parallel processes of individual and collective learning. Innovation processes do not only produce new products and processes; they also produce *enhanced individual and organisational competencies through various processes of learning,* taking place concurrently with the creation of novelties. New knowledge produced in innovation processes is not only incorporated in new products, processes, and services but also internalised by the people involved in the process and it is incorporated in organisation practices (Lundvall 1992).

Learning is essential for innovation to occur.[26] The capability to carry out innovation also brings with it the critical requirement for continuous learning. This is not reflected in neo-classical economic theory, which conceptualises innovation as decision-making based on a given amount of information (Miettinen 2001). However, innovation and learning are closely linked, they represent the two sides of the same coin. While innovation is the outcome of learning processes of social actors, successful application of innovations, on the other hand, depends upon learning processes of the social actors involved (Lundvall 1993). One can argue that "someone/something learns if the range of its potential behaviours is changed through processing of information" (Meeus and Oerlemans 1999, 125). Learning includes both the acquisition or self-creation of new knowledge (understanding/cognitive development) and the application of this new knowledge (doing/behavioural development) (Stahl et al. 1993, 11).

Innovation is associated with *reflexive learning* instead of simple learning. Simple learning takes place when actors react directly to emerging problems. Self-reflexivity, on the other hand, can be defined as "the possibility for groups of actors [...] to shape the course of economic evolution" (Storper 1997, 28). It means that actors do not blindly pursue the passion that moves them at the moment or merely execute social routines. Instead, self-reflexivity characterises the capability of actors to deliberately imagine and act on different strategies (Sabel 1997). They can exert influence due to the fact that they are capable of reflecting upon the functioning of their environment. This means more than anticipating new developments and considering them in the development of new strategies; self-reflexivity includes the monitoring of the environment, critically dissociating oneself from the traditional functioning of reality and developing alternative ways of acting (Sabel 1997).

Learning and knowledge creation can take place *at various social levels*. We can differentiate between individual and collective processes. Learning is first of all an individual process, but it does not take place only at the individual level.

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[26] Most scholars agree that innovation and learning are causally connected somehow, but insights in innovation and learning are spread across a wide field of literature.

Actually, as we have argued above, learning must be seen mainly as an interactive process, co-dependent on the communication between people or organisations with different types of required knowledge. Therefore, learning also occurs through firms and organisations on to inter-firm and inter-organisational learning, cross-institutional learning, and on to the whole system (Archibugi, Howells, and Michie 1998, 6). The inter-organisational perspective leads to such concepts as 'regional learning' or 'learning regions' (Florida 1995) or 'learning economy' (Lundvall and Johnson 1994).

Individual learning

Individual learning refers to the acquisition of information, knowledge, understanding, skills, and competencies by individuals through some forms of education or training (OECD 2000c, 12). The individual type of learning can take a variety of forms. We can here differentiate between *formal learning* within education institutions, such as schools, colleges, and universities or vocational education institutions, on the one hand, and experience-based informal learning on the other. Formal education is primarily concerned with the *dissemination of existing knowledge* (OECD 2000c, 13), although new approaches are increasingly aiming at combining education with the creation of new knowledge on a project basis. 'Know-what' and 'know-why' are the types of knowledge that are typically learned in formal education systems (Lundvall and Johnson 1994).

The two forms of knowledge and the types of individual learning associated with them constitute important prerequisites for innovation. For companies in so-called science-based firms, access to such a sophisticated type of knowledge is crucially important. It can imply decisive technological advantages that are necessary for companies to be first on the market with product or process innovations. Therefore, successful innovations in the so-called science-based industries to a great extent depend on whether the education system produces graduates with the required level of scientific and technological knowledge, who can then be recruited into firms and other organisations.

Also, the ability to develop new organisation models and management practices and to stimulate and support innovation processes to a great extent depends upon the availability of high-level knowledge to graduates in respective disciplines. Effective arrangements to guarantee the flow of graduates from education and training institutes to industry is a major element in securing the conditions for innovations to occur (OECD 2000c, 13).

Besides learning in formal education organisations, individual learning also takes place in a more *informal way,* as learning processes can be embedded in routine economic activities. "Such activities involve learning-by-doing, increasing the efficiency of production operation (Arrow 1962a), learning-by-using, increasing the efficiency of the use of complex systems (Rosenberg 1982) and learning-by-interacting, involving users and producers in an interaction resulting in innovations

(Lundvall 1988)" (Lundvall 1992). Rosenberg characterises 'learning-by-doing' as the development of skills in production (1982, 121). By differentiating between "gains that are internal to the production process (doing) and gains that are generated as a result of subsequent use of that product (using)" (1982, 121), Rosenberg explicitly includes the context of application of a new product. Both learning by doing and learning by using characterise the types of knowledge which cannot be deduced from scientific and methodological laws and principles; it cannot be learned through formal education processes. What individuals acquire is the capability to do things or to use them effectively and also to solve problems related to processes of doing and using. Experienced workers can 'try out a new thing', which can become a significant contribution to product and process innovations.

Knowledge generated in processes of 'learning by doing' and 'learning by using' is difficult to codify. Opposed to 'know-what' and 'know-why', this type of knowledge can be characterised as 'tacit' because it is tied to persons; it typically develops in specific 'communities of practice'. The fact that highly specialised 'know-how' developed in normal economic activities becomes the central resource of innovation poses some problems for companies, since it is difficult to develop strategies to promote knowledge generation through 'learning by doing' and 'learning by using'. However, increasing attempts have been made by formal education institutions promoting more general learning capacities to support and stimulate 'learning by doing' and 'learning by using'.

Still, the most effective way of producing and disseminating practical knowledge is through *'learning by interacting'.* Without enabling processes of interacting and exchanging information, tacit knowledge can hardly be diffused even within companies. In addition, by communicating with colleagues at the workplace and by exchanging information, people can learn new things and increase their knowledge. But learning by interacting can also include processes of communicating with clients or supplier firms. Of course, companies have to provide the organisational and cultural preconditions to gain from learning by interacting. But it is now widely acknowledged that firms can accumulate knowledge not only by managing knowledge flows from formal institutions through educating and training their workforce but also through fostering learning by interacting.

Organisational learning

Individual learning is naturally crucial in order for companies to increase their innovation capacity. But companies have to move beyond individual learning and stimulate *organisational learning* to substantially support innovation processes. Organisational learning creates knowledge to a much greater extent than individual learning. Organisational learning, of course, depends upon individual learning, but it is of a different nature, as *collective or organisational knowledge exists more between than within individuals*. "Creating knowledge organisationally", as Nonaka

and Toyama argue, "does not just mean organisational members supplementing each other to overcome an individual's bounded rationality" (2000, 3). Learning by interacting can be regarded as a step beyond individual learning, since through continuous exchange of information and knowledge among social actors, not only the participating individuals learn, but at the same time also the organisation may learn. Organisational learning "amplifies the knowledge created by individuals and crystallises it as part of the knowledge network of the organisation" (Nonaka and Takeuchi 1995).

Meeus and Oerlemans, referring to Dogson (1996), characterise organisational learning as "the ways firms build, supplement, and organise knowledge and routines around their competencies and within their culture, and adapt and develop organisational efficiency by improving the use of these competencies. Competencies are the focused combination of resources within a firm, which define its business activities and comparative advantages" (1999, 125). We can argue that organisational learning increases the organisational memory, which can be defined as stored information and knowledge from an organisation's history that can be brought to bear on present decisions (Walsh and Ungson 1991, 61). But organisational learning means more than an increase in the knowledge stock; it also includes the know-how to apply the knowledge for doing things and organising processes in a new and often very different way.

Organisational knowledge is embedded in organisational rules, practices, and norms but can also be stored as hard data in technical devices. Collective knowledge can be characterised as the collective mind of the organisation. Depending on the organisation form, it can be centralised or shared and distributed among the members of an organisation. In the second case, it represents knowledge in a state of flow, which emerges from the interaction of the organisation members. Organisational learning can take place in different ways. Besides the *experience-based learning by interacting* at the workplace, Foray mentions *learning by organised research*, as well as the *knowledge acquired and assimilated from external resources* (1997, 64). Thus, learning in a wider sense includes *exploring and searching* (Lundvall 1992).

Firms can learn by searching for already existing knowledge, which, combined with their knowledge stock, may lead to new products or processes. They scan the environment to search for alternatives to their present routines and for new activities (Saviotti 1997, 193). The transfer of knowledge can take place through the purchase of licences but also through less formal types of knowledge exchange in inter-organisational production chains.

The major mechanism by which firms learn about technology in the sense of exploring is through internal R&D efforts. However, as knowledge is becoming more complex and processes of knowledge specialisation take place, companies often lack the knowledge needed to generate major innovations. That is why *learning by exploring often takes place in collaborative research processes.* For example, companies more and more often form R&D consortia in which various firms cooperate with universities and research institutes to generate new knowledge as a basis for innovations.

A slightly different distinction is made between *first-order and second-order learning* (Hedberg et al. 1976) or between *single-loop and double-loop learning* (Argyris and Schön 1978). The first type of learning leads to an improvement or adaptation of existing practices, while the second type leads to a development of new practices. Both typologies are closely related to the distinction between 'exploitation' and 'exploration'. 'Exploitation' means the efficient use of available resources or competencies, while 'exploration' is associated with the development of novel resources and competencies (March 1991).

Firms must do both: to survive in the short run, they have to engage in exploitation, and to survive in the long run, they have to engage in exploration. The two strategies differ with respect to the control aspect; while exploitation requires maintenance of existing identity, knowledge and practices with a certain amount of control and coordination, exploration requires their change with a loosing of control and coordination (Nooteboom 1999a). In the following, we will first discuss the problem of integrating the individual and organisational levels of learning. We will then present a model which combines both processes: exploitation, or first-order learning, and exploration, or second-order learning.

Integrating the individual and the organisational levels: the *ba*-model

What is basic to the *ba* model is the idea of a self-reinforcing recursive process of the use and generation of knowledge (Nonaka 1994; Nonaka and Toyama 2000). Nonaka, the developer of the model, taking up the differentiation between 'tacit knowledge' and 'explicit knowledge' (Polanyi 1978), focuses on the process of 'knowledge conversion' (Nonaka and Takeuchi 1995), which means the interaction between these two types of knowledge. For him, tacit knowledge is more important than explicit knowledge. Tacit knowledge means personal and subjective knowledge; it is embedded in individual experience and action, and it involves personal intuition, emotions, ideals, and values. However, due to its specific nature, tacit knowledge is difficult to communicate.

Therefore, the main problem concerning innovation is how tacit knowledge can be transformed to be useful for the whole organisation, and on the other hand, how explicit knowledge can be transformed into personal 'know-how'. Nonaka deals with the question by differentiating between four modes of knowledge conversion, which in the case of an optimal process design can be connected into a 'spiral of organisational knowledge creation' (Nonaka 1994). The so-called SECI spiral goes through the following modes of conversion: (1) socialisation (from tacit knowledge to tacit knowledge; (2) externalisation (from tacit knowledge to explicit knowledge); (3) combination (from explicit knowledge to explicit knowledge); and (4) internalisation (from explicit knowledge to tacit knowledge).

The process of knowledge creation starts when tacit knowledge and experiences are shared at the group level mainly through close interaction and collaboration.

This *socialisation phase* creates common understanding and generates trust among group members. *Externalisation*, the second phase, is central to the process of knowledge creation because here tacit knowledge becomes explicated and conceptualised. This transformation happens mainly by using metaphors, analogies, and all sorts of figurative speech. In the *combinatory phase*, all explicit knowledge is combined and exchanged. But only if the existing explicit knowledge at the organisational level is *internalised into individuals' tacit knowledge and action*, does the knowledge creation spiral function effectively and changes in the behaviour and understanding of the individual may occur. When the process has ended, knowledge has been transferred from the individual to the organisational level and back to the individual level, while being transferred from tacit to explicit and back to tacit knowledge.

Nonaka's main argument is that a knowledge-based organisation is able to generate knowledge and innovation if it manages to transform the very difficult and demanding exchange processes between the two forms of knowledge into routine organisational processes. Through this, companies can support individual knowledge creation and its diffusion within the organisation. Recursive 'rounds of meaningful dialogue' and the capability to use metaphors, which can transform implicit knowledge into reproducible symbols, represent the mechanism that can support such processes (Nonaka 1994, 20).

Whether firms are successful in creating new knowledge depends, as Nonaka and Toyama argue, upon the following factors: *knowledge vision, organisation forms, incentive system, corporate culture and organisation routines, and leadership* (2000, 80—82). The function of a knowledge vision is to synchronise the entire organisation on certain knowledge domains. But at the same time, the knowledge vision needs to transcend the boundaries of existing products, divisions, organisations, and markets to allow for extensive knowledge exchange even among units with different interests.

Secondly, configuring the organisation in such a way that all types of knowledge conversion can be fostered and balanced is an important factor in determining the firm's capability to convert knowledge. *Incentive systems* can also affect knowledge creation within organisations, since they motivate or de-motivate organisation members to share knowledge.

Nonaka and Toyama mention *corporate culture and organisation routines* as the fourth factor that affects knowledge-conversion intensity within firms, because they determine how organisation members view knowledge and knowledge-creating processes and how they interact with each other. While corporate culture and organisation routines may support knowledge creation within a specific development path, they may, however, also become rigidities hampering future learning in new areas. Finally, leadership becomes an important factor affecting knowledge creation, as it integrates the above factors. According to the authors, *'distributed leadership'* where every member of an organisation can become a leader depending on the context is most supportive concerning knowledge conversion and knowledge creation.

The cycle of exploitation and exploration

We have argued above that to survive in the short and long run, companies need to both exploit their existing knowledge and competencies and to explore new ones. This means that they have to explore new opportunities while preserving their existing knowledge stock and competencies in such a way that exploitation is still possible. The question is, however, how can companies do that, how can they combine the two processes? How can they resolve the 'paradox of stability and change' and how can they set about creation with a minimum of destruction (Nooteboom 1999a)?

Nooteboom has developed a *cycle of exploitation and exploration*, extending the traditional 'life cycle theory of innovation' (1999b). The model starts with the *exploration of novel combinations*, which have to be consolidated into a dominant design. *Generalisation, differentiation, and reciprocation are the following stages* which lead up to a novel combination. In the end, the novelty has to be consolidated in a dominant design again.

The stage of consolidation means closing the variety of content. The consolidation stage is important in order to avoid to great turbulence, although it may develop into a 'lock-in' or inertia. Firms can hardly jump from one novelty directly to the next one, as such a process may become very difficult to manage. It is also counterproductive to give up practices that have functioned well so far as long as one does not know their limits and the possibilities of replacement.

During the consolidation stage, companies can identify the best practice of how to use the novel combinations of knowledge. This means that in the consolidation phase, the variety of content is closed down to enable efficient production and a clear paradigm as a platform for generalisation. Generalisation means that the new practice is diffused to a variety of novel contexts, during which process tacit knowledge turns to explicit knowledge. The practice then has to be adapted to the varying contexts, which results in differentations of the practice and reciprocation with parallel practices, including forms of exchange of elements.

Together with the adaptation of new practices to varying contexts complexity increases. This will result in complicating and slowing down the grasp and coordination of the whole; companies cannot benefit from the 'economy of scale' as elements of practices are developed in different places at the same time. And to preserve the functioning of the old parts, the traditional structures will impose constraints that will become a hindrance for full use of potential elements. The increasing chaos makes it necessary to develop a more radical architectural change with fewer elements and more clarity of structures. On the basis of preceding experiences with innovation processes, companies will be able to decide which elements to combine by what architectural principle. The whole process starts again, as the emerging new novel combination needs to be consolidated to become effective within the firm.

Nooteboom (1999a) discusses *various models to organise the 'cycle of exploitation and exploration'* (see also Schienstock 1975). For exploring innovative combinations while maintaining efficient production, various modifications of a matrix organisation have been developed. Other models are based on the principle of separation of place; one part of a firm engages in exploitation and the other in exploration. In such a model, governing the interface often becomes very difficult. Shepard (1967) suggests a two-state model, based on the principle of separation of time.

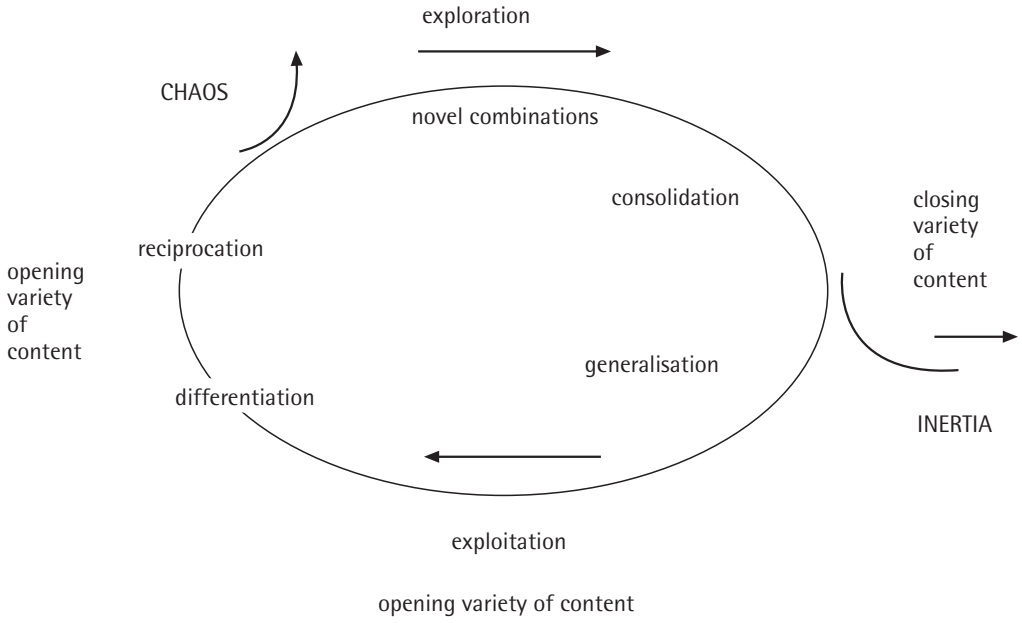

Figure 4. Cycle of exploitation and exploration. (Source: Nooteboom 1999a.)

Another model suggests *cooperation among specialised firms*. We can have firms that specialise in generating novel innovation and others that bring them up to large-scale and systemic rationalised production and global distribution. As we will see later, such a model is typical of knowledge-based industries. Often small, diverse biotechnology firms which yield novel combinations cooperate with pharmaceutical firms which yield the systemic, large-scale production and marketing of novel products (Nooteboom 1999a).

User orientation and communities of practice

Many theoretical and empirical studies, we have argued earlier, have highlighted the *active role of users* in the development of technology (see e.g. von Hippel 1988). Empirical findings demonstrate that the use of technology and its integration into work processes is a very active process. It not only requires learning and the development of competencies by the potential adopter, but in the introductory and in the later phases of using the technology very often modifications occur, and therefore, some kind of re-invention takes place. While producing things or providing services, users can develop their technology through experimental processes (Brousseau and Rallet 1998, 255).

From what has been said above we can conclude that new technologies do not enter production processes as completed and unchangeable artefacts. Instead, they are actively *interpreted and appropriated* by their users in the context of their existing work practices. By 'practice' we mean undertaking or engaging fully in a task, job, or profession (Brown and Duguid 2000). Based on this empirical evidence, Tuomi suggests a radical reinterpretation of the concept of innovation, taking the *user perspective* as a starting point (2001). Technological novelties, according to this concept, become innovations only when they start playing a role in *meaningful social practices*. But at the same time, innovation can only happen if *social practices change* together with the incorporation of new technologies. Things must be done otherwise, which not only implies changes in individual behaviour but also *restructuring of social relationships*.

Giving up the idea of innovation as a fixed technological artefact, products and processes become *'interpretatively flexible'* (Bijker 1987). Various user groups can interpret new technologies in different ways and give technological artefacts very different meanings. "Instead of being a well-defined objective artefact, with characteristics that could be described without reference to social practice the artefact in question has many, and possibly incompatible, articulations. These meaningful products may develop independent from each other, and one technological artefact can embed several meaningful products simultaneously" (Tuomi 2001). Innovation from a user-centric point of view therefore includes *three, though intertwined, dimensions*: the re-inventive application of a technology, the restructuring of social relationships, and the creation of a context-specific meaning of a product.[27]

[27] However, while the process of meaning creation is undoubtedly present, it does not comprehensively describe what new technologies are. These possess an objective set of rules and resources that both enhance and constrain the interpretation and use of new technologies. They also have an influence on social practices in which they are incorporated. To conceive of a social order as resting solely on interactions among human beings is to ignore the role that material resources play in shaping and substituting for social relationships (Kavangh and Arujo 1997).

Innovation consists of a variety of different functions or sub-processes; they represent a *system of complementary types of innovation practices*[28]: basic research, applied research, manufacturing, marketing, and others. Practices are communally and directly shared by an interdependent group of people (Brown and Duguid 1999). Actors participating in these practices form different kinds of communities involved in specific tasks and functions, which means that, in order for innovations to succeed, practices in all communities involved have to change concurrently. "[...] we should", as Tuomi argues, "understand innovation as a *multi-focal process of development* where an *ecology of communities* develops new uses for existing technologies, at the same time changing characteristics of these technologies and their own practices" (2001, 33, emphasis added).

Innovations, we can conclude, are not generated by scientists or engineers only. Instead, innovation has many agents and innovation is distributed in time, space, and across various user groups; it emerges out of interactions among several communities of practice. While these communities have the advantage of tying their members together and giving them a common orientation, they also develop distinct loyalties and identities that are not shared by all organisation members. Having their own internal dynamics, innovation practices may result in participants' attempting to distinct their practices from other innovation practices and the rest of the organisation. Therefore, tacit knowledge may be exchanged among members of a particular innovation community, but not with organisation members of other communities also involved in innovation processes crystallising around different functions. This can explain why innovation processes often lose momentum within organisations and get stuck.

Employees not only become involved in different innovative communities; in general, they are also members of a much larger group of people, doing similar things within other organisations. They are part of *larger occupational groups or groups of experts,* being engaged in similar practices, which have developed specific norms, values, and world-views. These larger groups, unlike communities of practice, do not coordinate their practices directly. Instead, they form what Brown and Duguid call a *network of practices* (1999)[29]. These are less tightly linked than communities but still they share common practices, allowing some kind of knowledge dissemination. It is, therefore very likely that innovative ideas and 'know-how' in exploiting new knowledge will spread across organisational boundaries if common trans-border practices in networks of occupational experts have already been established. Depending on the tightness or looseness of connectivity among members in networks of practice, of course, knowledge flows are more or less intensive.

The concepts of 'communities of practice' and 'networks of practice' reveal two major problems related to innovation processes. While the concept of communities of practice may explain where and *why knowledge sticks* within companies, the

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[28] For different concepts of social practice, see Tuomi 2001.

[29] For a critical discussion, see Tuomi 2001.

concept of networks of practices can give hints about where and *why knowledge leaks* (Brown and Duguid 1999, 12). As specialised innovative practices tend to become isolated and communities of practice aim at distinguishing themselves from the rest of the organisation, they often become a hindrance to intensive communication and knowledge exchange, with the consequence that companies are confronted with a coordination problem. Companies have to overcome the problem of knowledge sticking between communities of practice by implementing effective coordination mechanisms. Lately the *concept of discursive coordination* has been suggested as an efficient mechanism for coordinating various practices in an innovation process (Schienstock 1999). The aim of discursive coordination is to stimulate learning processes through mutual monitoring.

The fact that knowledge leaks despite organisational barriers where close ties within expert networks have developed, causes the second major problem in an innovation process. On the one hand, it is important for companies to get access to outside knowledge to improve and accelerate innovative activities, which can take place most easily if their employees become involved in various expert networks. New, even revolutionary ideas, although published in articles or books, will hardly spread as long as the practice that makes abstract knowledge truly intelligible is not known. On the other hand, exactly this membership may cause a loss in tacit knowledge, as this will be shared with other experts outside the company in occupational networks. To avoid the leaking of highly valuable knowledge, particularly to competitors, companies have to develop specialised knowledge which is difficult to copy.

Linux and the open source development model[30]

In recent years, a new innovation model has emerged, challenging many of the assumptions and theoretical fundamentals of traditional innovation models. The so-called 'open source development model' has a major impact in software and Internet-based industries. The Linux operating system represents a good example of innovation processes taking place under conditions of the *'open source development model'*.

The basic idea of this model is that a complex technical system is created by a great number of people forming a *developer community*; here often users and producers become the same (Castells 2000). Development of the technical system takes place within an informal, self-organising social community. The members of this community constantly develop the technical system by reporting bugs and

[30] This section draws heavily on Tuomi (2001).

expressing ideas for new functionality. The participation of a great number of people from all over the world in the development process leads to the fast growth and increasing complexity of the system. While new innovations can be incorporated into new releases without major delay, the dynamic development causes increasing problems with respect to the *manageability of the system*. The *tension between continuous innovation, stability, and functionality* is a critical issue for the open source model. Serious coordination and control problems are related to this issue (Tuomi 2001).

Forms of coordination and control co-evolve in a process of social and technical structuring. To put it simply, the Linux system consists of an operational kernel and system utility programmes and applications. To avoid loosing controllability, changes in the core kernel happen only in limited ways if they are compatible with the old structure, as otherwise each time extensive rewriting of other parts that rely on the functionality would be necessary. While tight control of the operational kernel is absolutely required, other parts of the system are open for further development and can be extended.

As it is not technically possible to limit changes, the functioning of the open source model depends on strong forms of social control. The control function is taken over by an internal group of core developers, which substantially and successfully contributed to the core of the system. Group members intensively discuss the problems of further development of the system via the Internet. Tuomi characterises the Linux developer community as a *dynamic meritocracy*, in which authority and control are closely associated with the produced artefact (2001). In addition, a great number of people contribute to the further development of the system by developing new peripheral additions. These are not controlled by the core developer group; however, to get a programme accepted as an interesting sub-system, the involvement of a group of co-developers is needed, which means that control is related to the capability to mobilise resources.

Modularisation has become the key concept of technological development; a programme has been developed that minimises interactions between modules. Social agreements, mostly informal and reflected in overall practices, guarantee that programmeming takes place in such a way that it does not create problems for other programmes. One can only become an accepted member of the Linux community if one has demonstrated mastery of the key rules controlling the development of the system.

Quality control in the open source development model also differs from traditional control strategies as, due to the principle of openness, users not only report bugs and make complaints; they can be more actively involved by becoming system developers. Those who have the best 'know-how' can easily solve problems that occur and are reported by others. While in traditional models problem solving can become a difficult and long-term process, in the open source development model this can often be done very quickly, as a multitude of users is eager to contribute to the problem-solving process. Problems become a great challenge for programmers, and finding solutions can be interpreted as some kind of a game

(Buraway 1979). People fully commit themselves to the process of problem solving, highly motivated by the challenge to find a solution, while they have to obey general rules. Furthermore, successful creators of a new piece of software integrated into the system are rewarded by the acknowledgement of their mastery in the developer community. Due to such kind of incentives, the open source development model is likely to provide the best solutions for emerging problems, which guarantees the high quality of the technical system.

At the same time, *individual learning and organisational learning* are closely linked. First, problem solving often takes place through interactive learning, as, in general, a group of programmers becomes involved in the process. Second, as it is often difficult to anticipate consequences of programme changes for different system components, complex testing processes involving multiple configurations take place to avoid extensive adaptive work. Quality control in the evolving system becomes a process of continuous innovation and individual and collective learning based on overcoming arising problems.

Most of the Linux system development occurs without economic transactions. While the incentives and drivers of technology in the traditional innovation model are understood to be economic, the incentives in the case of Linux are mainly social. Social prestige, reputation, and attention become the main incentives in finding a solution for bugs and in developing new pieces of software; they therefore represent the key aspects to resource allocation. Economic exchange is replaced by social exchange. Often the concept of a 'gift economy' is used to characterise the new emerging economy. In the case of an open source development model, programmers of new software present their gifts to the developer community; they do not expect to be rewarded immediately but will gain from the gifts presented by other members to the community. Therefore, free-rider behaviour is not tolerated; members of the community trust each other in that nobody has the intention to take advantage of benefits brought about by collaboration without contributing actively to the development of the system.

The way in which property rights are handled in the open source development model represents a key social innovation (Tuomi 2001). According to the model, some common intellectual property rights, such as protecting the inventor from competition and securing an unchallenged use of an invention for some years, are intentionally reversed. The idea of the open source development model is to legally guarantee the ongoing re-use and further development of software through users. Free software licences guarantee various rights to use, modify, and distribute software. In addition, several implicit and explicit expectations exist, forming some kind of social contract, underpinning the idea of using property rights to enable symbiotic development instead of competition (Tuomi 2001).

Conclusion

Innovation, we can conclude, concerns all activities from the search for a solution of technical or other problems to the situation in which a new product or production process has been launched on the market. The process, however, does not unfold in a linear way; there is no definitely plotted temporal sequence of sub-processes, which have to be passed through one after the other. Instead, we can speak about a non-linear concept of innovation. It is often a process of moving back and forth between invention and/or design, development and testing, redesign and evaluation of market potential, which means that innovation processes are of a recursive nature, during which specific activities can become both causes and effects, consequences and prerequisites. The non-linearity can to a great extent be explained by the fact that one of the most salient features of innovation is uncertainty. Of particular importance are technical and market uncertainties.

Innovation research mainly deals with technical innovations, but the concept is not restricted to them. Actually organisational and institutional innovations represent an even more valuable asset, as they can hardly be copied and therefore guarantee sustainable competitiveness. The different types of social innovation are closely linked. For example, changes in the institutional support structure but also in cognitive frames are needed to make new organisation forms function effectively. Together with the growing importance of services, the focus of creating novelties, needs to be even more on social innovations.

Innovation processes do not only produce new products, production processes, or services; they also produce enhanced individual or organisational competencies. Learning can be seen as the other side of the coin, as processes of individual and organisational learning take place together with the creation of novelties. However, companies have to move beyond individual learning and stimulate organisational learning to trigger continuous innovation processes. To transform the process of converting tacit knowledge into explicit knowledge and back into tacit knowledge into a routine organisational process can be seen as the key problem of combining individual and organisational learning. But companies also need to combine processes of exploiting existing knowledge and expertise important for short-term survival with processes of exploring new knowledge, which is crucial for long-term survival.

The recursive nature of innovation suggests conceiving of innovation as the result of a division of labour. It is a highly complex process that involves people of different expertise and capabilities forming various communities of practice. Innovations represent a system of complementary types of innovation practices. Major organisational problems occur within companies, as various communities of practice hardly communicate with each other, while they often exchange knowledge with larger occupational groups, to whom they belong. Innovation processes

therefore often get stuck within companies, while knowledge is leaking through expert networks despite organisational barriers.

In recent years, the so-called open source development model has emerged, challenging many of the assumptions and theoretical fundamentals of traditional innovation models. The basic idea of the model is that a complex technical system is created by a great number of people forming an informal, self-organising developer community. While the model has a major impact in software and Internet-based industries, the extent to which it is also applicable to other industries needs to be analysed.

5 THE NATIONAL INNOVATION SYSTEM

The concept of a 'system of innovation'[31] is now widely accepted as a fruitful approach to analysing innovation processes and technical change and has even influenced policy makers on regional, national, and European levels. The concept was introduced by (Lundvall 1985), but the first widely diffused publication that used the concept of 'national innovation system' was Freeman's (1987) analysis of Japan's outstanding economic performance and technology policy. Freeman (1988), Lundvall (1992), Nelson (1993), and Edquist (1997) have further developed the concept. The application of the system concept in innovation research is motivated by the aim of *capturing the systemic, interdependent character of innovation, and technical change* (Soete and Arundel 1993; Freeman 1997). The approach, therefore, integrates a number of different factors that shape and influence innovations, including organisational and institutional ones, and it also stresses their interdependency and mutual interaction. The basic assumption is that it is the combined operation of a number of different factors that gives rise to technical and other innovations.

As one would expect with such a new concept, a precise definition of the innovation system is still emerging. The concept is characterised as conceptually diffuse, since the approach is associated with various kinds of ambiguities (Edquist 1997). There is no general agreement about the core concepts of the approach, nor what their content should be. On the other hand, the openness of the approach allows conceptual changes and the integration of new concepts, and it is possible to raise new research questions.

In the following, we deal with both unresolved conceptual problems and new research perspectives. For example, no sharp guide is given to what exactly should be included in a system of innovation and where to draw the boundaries. Furthermore, little attention has been paid to the problem of relationships among actors in the system and to forms of governance. And, while it is widely

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[31] For different definitions of the concept, see OECD (1997).

acknowledged that, parallel to the national innovation system, new systems of innovation have emerged on the regional and trans-national level, their particular relevance and interdependency is not discussed very intensively.

On the other hand, new concepts have been integrated, new perspectives have been developed, and new research questions have been raised. Taking into account that the innovation system is an open system, it has been suggested that research should focus more on the exogenous dimension of the innovation system and analyse the system of innovation as a subsystem of the economy and wider society. Social capital has been discussed as an important prerequisite for developing a sustainable innovation system. The role of KIBS (knowledge-intensive business service) firms in the innovation system is not well understood and needs further research. And the 'lock-in' phenomenon as the negative side of path dependency has been increasingly analysed, which has turned more attention to problems of path creation. In the beginning of the chapter, we will shortly discuss the system concept itself.

The system concept

The innovation system concept applies the term 'system' as a *heuristic device*; it helps to develop a conceptual framework for analysing operational entities. By means of this concept, entities are constructed; these constructs, however, never represent the totality of a real social phenomenon. What is specific about this methodology is that operational entities be it companies, regions, or nations, are analysed from a perspective focusing on their elements, on the relationships among these elements and their interaction with their environment. The general systems theory refers to "complexes of elements or components, which mutually condition and constrain one another, so that the whole complex works together, with some reasonably clear defined overall functions" (Fleck 1992, 5).

If we define a system as a set of concepts being more closely related to each other than to external variables, then an innovation system can be viewed as being made up of variables, related through their common link to innovation processes rather than with other forms of economic activities.[32] Consequently, Metcalfe defines a national innovation system as the "set of distinct institutions which jointly and individually contribute to the development and diffusion of new technologies and which provide the framework within which governments form and implement policies to influence the innovation process. As such it is a system of interconnected institutions to create, store and transfer the knowledge, skills and artefacts which define new technologies" (1995, 410).

[32] Edquist's (1997, 2) argument that the innovation system approach includes *all* the important factors that shape and influence innovations ignores the fact that the system approach analyses processes of technological and other changes from a specific perspective, and is therefore highly selective concerning the variables included in the approach.

The innovation system as a knowledge-transforming system

We can specify innovation systems as *open systems* (Lundvall 1992), which means that they have exchange relationships with their environment. Innovation systems receive inputs from their environment and they produce outputs for the environment in which they are embedded. In doing so, they not only influence their environment but they also shape their own external conditions at the same time.

Knowledge can be seen as the most crucial input to innovation systems. To be able to develop new products and processes, actors need to have new knowledge at their disposal. Knowledge may take the form of *new ideas and concepts*, *new skills or competencies*, or *technological and organisational advances*. Of course, in concrete innovation processes, external knowledge is combined with internal knowledge, which has been accumulated in earlier innovation processes. Cohen and Levinthal (1990) point out that substantial *'absorptive capacity'* is needed in the form of complementary skills and investments in order to make use of 'public scientific knowledge'. System theory then speaks about with-input.

Knowledge is not only an input factor but also an *output factor* of innovation systems. What gives an innovation system the sustainable advantage of being capable of exploiting existing knowledge and of creating new knowledge out of existing external and internal knowledge is also knowledge rather then just a set of technologies produced by the system at one point in time (Lundvall 1992). Knowledge in the form of new ideas and concepts, however, does not contribute to economic growth as long as it is not incorporated in new products, services, or processes. "Technological innovation", as Edquist argues, "is a matter of producing new knowledge or combining existing knowledge in a new way — and transforming this into economically significant products and processes" (1997, 16).

As we have argued earlier, the process of knowledge generation and knowledge application within innovation systems produces both product and process innovations as well as *enhanced individual and organisational competencies* as outcomes (Lundvall 1992). This means that together with the process of transforming knowledge into new product and process technologies, learning processes are taking place, both at the individual and organisational level. People and organisations learn and develop their competencies while being involved in developing technical and other innovations.[33]

Different types of knowledge

Knowledge, as we have argued, is an input as well as output factor. However, knowledge is not a clear-cut concept. Scholars often apply different concepts of

[33] See Chapter Four.

knowledge and they distinguish between different types of knowledge. The distinction between *tacit or personal and codified*[34] *or explicit knowledge* has gained some prominence in the debate on innovation processes.[35] Differences between codified and tacit knowledge lie in three major areas: *codifiability, methods of acquisition, and the potential for aggregation* (Lam 1999).

Explicit knowledge can be characterised as declarative knowledge or clear-cut normative procedural knowledge; it is related to factual and descriptive statements. As general knowledge it can be easily encoded and packaged, which reduces the costs of knowledge exchange. Ease of communication and transfer is the fundamental property of codified knowledge (Lam 1999). Lundvall and Borrás interpret codification of knowledge as transformation of knowledge into information; as such, it can easily be transmitted through information structures (1997). Compactness and standardisation make it possible to transfer explicit knowledge over great distances and across organisational boundaries (David and Foray 1995).

Because explicit knowledge can be easily codified, it can be aggregated at a specific location and stored in objective forms. The appropriation of explicit knowledge can take place without the participation of the knowing subject (Lam 1999). Due to its general character, explicit knowledge cannot be easily protected (Raivola et al. 2001). Explicit knowledge is in principle universally available. But, to acquire this type of knowledge, one often needs closer contact with existing stocks of codified knowledge and with knowledge institutions.

Tacit knowledge[36], on the other hand, refers to knowledge that is intuitive and unarticulated. It cannot be transferred easily because it has not been stated in an explicit form (Lundvall and Borrás 1997). Tacit knowledge is process-related knowledge: it is aimed at *activity,* not at a definite stage. In addition, tacit knowledge is in a state of perpetual change and it constitutes a filter through which new knowledge is assimilated (Raivola et al. 2001).

Polanyi characterises skills as an important type of tacit knowledge (1958). Employees acquire tacit knowledge in their daily work through 'learning by doing', 'learning by using', and also through 'learning by interacting' with their colleagues. Tacit knowledge cannot be easily aggregated and stored in an objective form; appropriation takes place through direct application (Lam 1999). According to Polanyi (1958), tacit knowledge and codified knowledge cannot be understood as separate types of knowledge; instead, they represent two different dimensions of knowledge. Although it is possible to make a conceptual distinction, in practice, they are not separate nor discrete.

The typology developed by Lundvall and Johnson (1994) differentiates between four types of knowledge: *know-what, know-why, know-how, and know-who*. Know-what refers to facts, it is close to what is normally called information. Know-why

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[34] This distinction goes back to Polanyi (1958).

[35] Here we do not discuss additional concepts of differentiating between various forms of knowledge. See Hakkarainen et al. (2001) and Raivola et al. (2001).

[36] For a further distinction between various types of tacit knowledge, see Spender (1996).

refers to knowledge about principles and laws of motion of nature in the human mind and in society, and is therefore extremely important to technological development in certain science-based areas. The concepts of know-what and know-why correspond to a great extent to codified knowledge.

Know-how refers to skills, the ability to do something. But know-how cannot be characterised as practical rather than theoretical. Some kind of know-how is necessary even in scientific work. Know-how is typically kept within the borders of an individual firm or a single group of organisation members, but it increasingly extends to networks of organisations. Due to processes of specialisation in networks and the increasing dependency on complementary knowledge, know-who becomes more and more important. People need to know whom to contact to solve specific problems. Know-how and know-who correspond to a great extent to tacit knowledge.

Sticky knowledge as competitive edge

It has often been argued that tacit knowledge represents the principle source of *sustainable advantage* in an increasingly dynamic and turbulent business environment (Grant 1996; Winter 1987; Prahalat and Hamel 1990). To hold their own in global innovation competition, companies have to develop a tacit knowledge base, which may allow them to earn extra rents for a longer period of time. However, there is also a tendency towards an *increasing codification of tacit knowledge* (Maskell et al. 1998). Through this codification process, tacit knowledge becomes more and more globally available, which means that an advantage based on the development of tacit knowledge may sooner or later disappear.

On the other hand, it is never possible to codify all kinds of tacit knowledge. Some knowledge is internal to the human being and can only be documented to a certain degree. There is, we can argue, a natural limit to making know-how, defined as the ability to do something, explicit. Furthermore, a lot of accessible explicit knowledge can only be used by skilled people, which limits its dissemination significantly. In addition, a lot of organisational knowledge existing as routines, habits, and informal procedures in firms has developed spontaneously through communication within and among companies. The more important such kinds of non-codifiable or less codifiable knowledge become for companies' competitiveness, the more knowledge in general becomes explicit and is put into use by a growing number of firms at an increasing speed.

Companies that rely only on tacit knowledge, on the other hand, may face major problems. Survival in a global economy cannot be guaranteed by only small changes; based on long-term goals and strategies, companies have to put into practice also more radical innovations, incorporating codified R&D-based knowledge. There is a great risk that by only continuously upgrading their tacit knowledge and existing products companies will lose out in periods of major technical changes and economic instability, when more radical innovations are needed. Incremental

changes based on tacit knowledge will not be sufficient to secure long-term competitiveness of companies (Asheim and Isaksen 1999). When knowledge is changing rapidly, companies have to take part in its creation to make sure that they have access to it, in order to put more radical innovation into practice.

A strict distinction between tacit and codified knowledge, however, may actually not be useful. Codified knowledge can be very similar to tacit knowledge by nature. An important part of codified knowledge, like tacit knowledge, emerges out of local interaction and is therefore geographically less mobile. It may be characterised as '*sticky' knowledge* (von Hippel 1994). Such *codified and locally embedded knowledge* may be an important resource (Asheim and Isaksen 1999), which companies can use in addition to their own tacit knowledge, in order to put more radical innovations into effect. The adaptability of this 'sticky' knowledge, on the other hand, is very much dependent upon and limited by tacit knowledge. It is important, we can conclude, that companies not only rely on their tacit knowledge as its continuous upgrading only allows incremental innovation. Codified knowledge, on the other hand, can hardly become the basis of major competitive advantages, as it is more or less available to all companies. *Codified but locally embedded knowledge* may enable companies to put more radical innovations into effect but as it emerges out of local interaction, it is still geographically less mobile and therefore remains a particular advantage.

Unresolved questions and new perspectives

Actors and governance in the innovation systems

According to Nelson (1993), the innovation system approach primarily concerns *organisations*. Systems of innovation are conceptualised in terms of the organisations involved in innovation and their inter-relationships; they are social systems (Lundvall 1992, 2). For a long time, the social dimension of innovations was ignored, as technological change was treated as a socially exogenous phenomenon. Conceiving of technological change as socially embedded means that the innovation process is not driven by an inherent technological logic. Instead, it emerges out of *processes of interaction* among social actors. The process of transforming knowledge into new products and processes always involves various social actors from different parts of the economic structure.

A *narrow definition* of an innovation system identifies the R&D departments of firms, universities, research institutes, technology transfer institutes, and government agents involved in technology and innovation policy as social actors.

Only those organisations are included that are directly related to the process of search for new knowledge (Lundvall 1992). However, there are scholars suggesting a wider definition of the innovation system. 'Higher-level organisations', as Teubal argues, may be needed that aim to facilitate learning processes and that can provide additional input into the innovation process (1998). Therefore, in pursuit of technological innovations, companies interact with support organisations to gain, develop, and exchange various kinds of information, knowledge, and other resources (Edquist 1997; OECD 2000c). Examples of support organisations include schools and training organisations, investment banks, and economic associations.

Although most researchers agree on the application of a wider concept of innovation system, it is obviously difficult to determine what should be included in the innovation system and what could be left out (Nelson and Rosenberg 1993, 4—5). We will demonstrate this by referring to universities. It is hardly controversial that universities represent an important actor in the innovation system since they produce scientific knowledge which becomes the basis for major innovations. However, universities also have other functions, such as high-level critical research and education instrumental for the national culture; they are only *partly included in the innovation system*; their contributions to other systems of our society are also very crucial (Nieminen and Kaukonen 2001). Overemphasising the actor status of universities in the innovation system may have the consequence that their other functions in our society are neglected (Miettinen 2001).

Problems associated with the identification of the key actors in the innovation system and the drawing of system boundaries demonstrate the *high ambiguity of this approach*. Here we suggest a focus on *specific functions in the innovation process* in order to avoid conceptual problems of boundary setting. We suggest distinguishing among the following functions*: knowledge creation, knowledge acquisition, knowledge distribution, knowledge regulation and standardisation, knowledge application, and knowledge use*.[37]

The functional perspective has several advantages. On the one hand, particular organisations are not associated with a specific task in the innovation process. They can carry out different functions within the innovation system and they can also contribute to other systems in our society. Innovation functions, on the other hand, can be pursued by different organisations concurrently; for example, firms are increasingly involved in processes of knowledge regulation, earlier a domain of public agents.

Furthermore, a functional perspective allows identifying those areas in which specific national innovation systems do *not have appropriate institutions*. And because countries may differ in the organisational solutions for specific problems in the knowledge creation, diffusion and use process, the functional perspective also *provides a good basis for comparative research and policy learning.* It allows

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[37] Of course, this differentiation is only analytical. Here we have differentiated between knowledge application and knowledge use. While application of knowledge is related to product or process development, knowledge use means the integration of an innovation into an existing structure and its routine use.

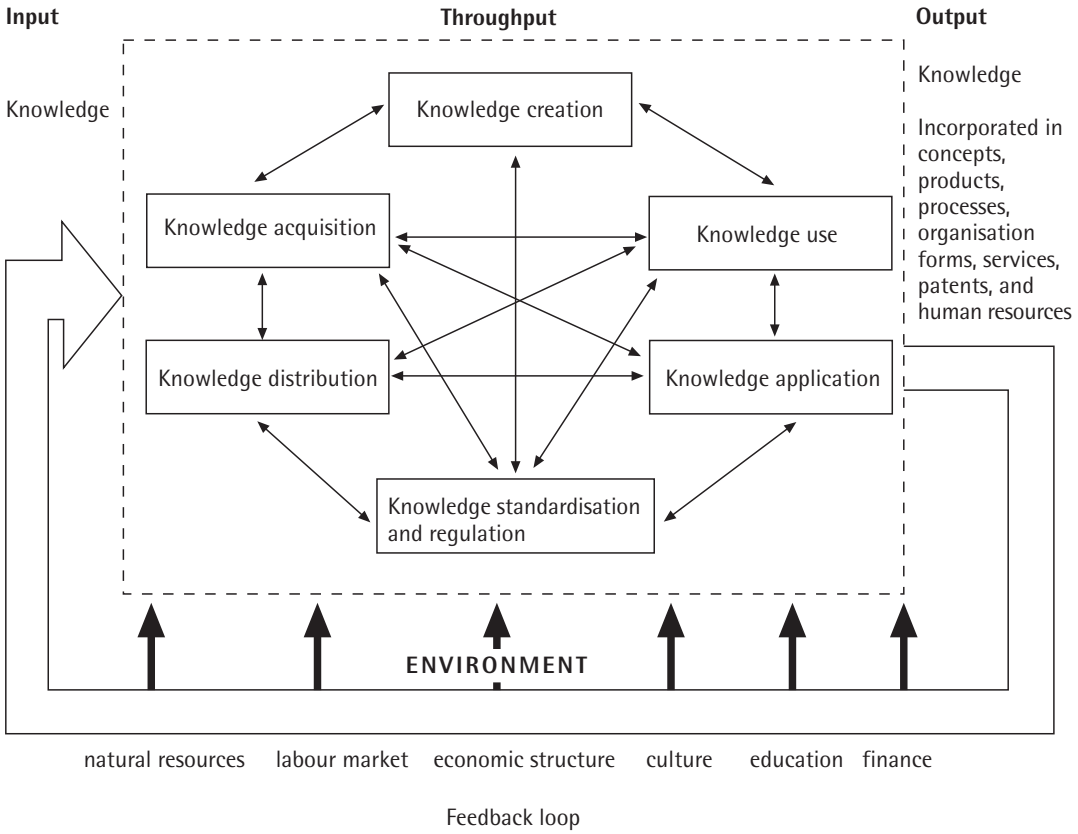

Figure 5. Functional perspective of the innovation system.

us to identify *functionally equivalent institutional solutions* in various systems of innovation.

The system concept represents an approach "in which interdependencies and interaction between the elements in the system is one of the most important characteristics" (Edquist 1997, 21). "The important theoretical and policy problem posed by these systems is that innovations are generated not only by individuals, organisations, and institutions, but by their, often complex patterns of interaction" (Saviotti 1997, 180). To understand why systems of innovation differ concerning the economic success achieved by them, it is not sufficient to only enumerate the actors and elements of the system and to describe their resources. Instead, we have to *take into account the relationships and interactions between these actors* (Johnson 1997, 37).[38]

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[38] It is often argued that it is increasingly important to focus on concrete interactions between firms and to involve detailed mapping of the interactive dynamics involved in specific innovation activities (Miettinen et al. 2001). We do not underestimate the value of those case studies but here the perspective is more general seeking to link the dynamic processes with the transformation of the economy. Therefore, we will focus on institutionalised forms of cooperation and use the concept of governance.

Saviotti argues that networks "constituted by a set of actors and by the links connecting them, are an analytical category that allows us to study more systematically such patterns of inter-individual interactions. In this sense, networks represent the structure of a social system" (1997, 194). Some definitions of the innovation system explicitly entail the term network. Freeman, for example, defines a national innovation system as "the network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies" (1987, 1). Similarly, Foray speaks of a knowledge system as a network of actors (1997, 64).

The network, however, is just one form of governance in innovations systems besides markets and hierarchies. To what extent innovation systems produce technical and other novelties depends on the specific type of governance relationships. The innovation dynamics in horizontal forms of network relationships between research institutes and companies, for example, is radically different from the dynamics in hierarchical relationships. [39] Those scholars defining innovation systems as a network of actors need to explain why the network is the typical, and probably the most effective, form of governance in innovation systems.

Some scholars have recently pointed to the key role of social capital in innovation processes (Lundvall 1998). High innovation dynamics, it is argued, depends on trust-based relationships and the high amount of accumulated social capital as the production of novelties often involves intensive exchange of confidential information and tacit knowledge. Social capital and trust-based relationships, on the other hand, are most likely to develop in decentralised horizontal forms of cooperation between firms. Inter-firm networks, we can conclude, probably produce a high innovation dynamics, as they are based on trust relationships, while market and hierarchical structures are not well suited for the accumulation of social capital. Being based on distrust relationships they may become a major hindrance factor for innovation to occur.

Another perspective refers to social capital as a quality of 'civil society'. The argument here is that societies differ with respect to the accumulated social capital and that this has an impact on their capability to produce intellectual capital and to engage in innovation activities. "Social capital is assumed to be proportional to the density of relationships among citizens and specific weight is given to the frequency of participation in organisations [...]" (Lundvall 1998). The fact that in small countries dense and frequent links between people and organisations exist may explain their relative economic success. As their institutions provide the basis for the development of trust and the accumulation of social capital, we will probably see intensive cooperation among involved organisations and open knowledge exchange supporting interactive learning and collaborative innovation processes (OECD 2000c).

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[39] For an intensive discussion of the various governance forms and their advantage, see Chapter Eight.

The exogenous dimension of the innovation system

To analyse the *exogenous dimension of the innovation system* means that we have to understand the *innovation system as a part of the wider economic system*, a perspective, which remains relatively undeveloped. As a subsystem of the economy, the innovation system has a particular focus: *the generation of change in the economic system, by producing new knowledge* (Hauknes 2000). The major function of the innovation system, we can argue, is to contribute to the creation of growth and social welfare within an economy by producing knowledge that is used particularly to *modernise and renew the production system*, its products, services, and processes. Therefore, the innovation system contributes only indirectly to economic growth and competitiveness.[40]

Of course, to some extent, innovations are also produced through processes of 'learning by doing' and 'learning by using' directly in the production system itself. While the emergence of specialised subsystems was seen as an important phenomenon of modernity, we can now identify a new element of modern societies. Specific functions of an economy or society are no longer the domain of specialised subsystems only; instead, *polycentricity* becomes a more common phenomenon. This means that while specialised subsystems are still important, they are increasingly forced to cooperate with other subsystems in carrying out their particular function.[41]

Besides being linked to the *production subsystem*, the innovation system is also connected with other subsystems of the economy: the financial system and the labour market. There is some evidence that the *financial system* is becoming increasingly important for innovation processes (OECD 1998a). In a transition period, new technology-based firms have an important role to play as major contributors to radical innovations. As new businesses they have to invest heavily in R&D, production facilities, marketing, and branding, for which they need venture capital provided by the financial system.

The function of the *labour market* is to effectively allocate the existing skills and competencies within an economy. A shortage of skilled people, for example, will reduce the capacity of innovation systems to produce new knowledge and to develop new products, services, process technologies, and other innovations. Therefore, the labour market needs to provide incentives for qualified people to seek for jobs in the innovation system. Of course, the functioning of the labour market is limited by the structure of the human capital available, produced within the education system.

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[40] Nelson criticises that there are sets of intertwining terms and characterisations which make a focused analytical discussion very difficult (1993: 518). Particularly the fact that innovation systems are directly associated with competitiveness, growth, and social welfare is seen by him as a major problem. It is important to be able to regard innovation apart from the overall competitiveness of national economies.

[41] Here the problem of boundary setting becomes visible. While some scholars interpret these learning processes as part of the innovation system, others define them as part of the production system.

For the innovation system to function efficiently, also relationships to other social systems are crucially important. Here we can mention the science system, the education system, and the legal system. Innovation, as the OECD (1998a) states, is different from *science*[42]. An important function of the science system is to avoid underinvestment in innovation relevant knowledge. As science-based industries develop rapidly, companies increasingly draw on advances made by the science base.[43] Companies' innovation activities need to be nurtured by new scientific knowledge. Co-ordinating and merging localised knowledge with new scientific knowledge is becoming a core aspect of modern innovation processes.

The argument of a 'skill-biased technical change' (Breshnahan, Brynjolfsson and Hitt 1999) clearly indicates the importance of the *education system* for dynamic innovation processes. A shortage of specialised skills and competencies can become a crucial factor hindering innovation processes and economic growth. The education system has to react not only to signals from the labour market but also to the long-term trend towards a knowledge-based economy to keep the innovation dynamics going.

The general function of the *legal system* is to create a body of rules to satisfy the need for order and stability. But legal norms also regulate innovation activities directly or indirectly. Currently, property rights and the competition law are becoming an important issue, related to innovation activities. For example, the changing nature of competition, in which the success of companies increasingly depends on their innovation capacity, has become a challenge to the existing competition law. Although the function of the competition law is not to foster innovation, it should at least not hinder, but rather facilitate the development of novel products, services and processes.

So far innovation research has hardly considered potential negative feedbacks of product and process innovations (Lundvall and Archibugi 2001; Hage 1999). But, we cannot, for example, treat innovation automatically as a *positive-sum game* (Boden and Miles 2000). Instead, we have to look at problems and strains related to the increasing innovation dynamics. It is important to identify unintended consequences of a growing innovation dynamics as they may actually question the advantages and gains derived from innovation.[44] The innovation dynamics may create new jobs, but a 'skill-biased technical change' may also increase the risk of social exclusion for specific groups of employees (Schienstock 2001). Freeman (1997) has pointed out recently that the *ecological challenge* ought to be integrated into all strategies for economic development.

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[42] Again, we are facing the problem of boundary setting. The science system is often understood as part of the innovation system (for a discussion of this problem, see Nieminen and Kaukonen 2001).

[43] See Chapter Two.

[44] Schumpeter (1942) already mentioned the fact that innovations always have a negative side. He, however, saw the destruction of existing economic structures as a necessary side effect of innovations.

When analysing the performance of innovation systems, we can conclude, a wider concept of competitiveness has to be applied, taking into account the concept of *sustainable development*. We here do not understand the sustainability concept in a narrow ecological sense; instead, we refer to the so-called *'three-column model', which integrates the ecological, social, and economic dimension in a holistic way* (Schienstock 1999). This means that not only must the production system have the capability to absorb new knowledge but the use of new knowledge must also be consistent with ecological and social demands. *Possible negative feedback and frictions* in the innovation process, resulting from a non-sustainable development, need to be analysed more carefully. We also have to search for new institutional requirements to deal with these problems.

From what has been discussed above, we can conclude that the innovation system approach needs to focus more on the role of the innovation system in the economy and its interrelationship and interaction with other subsystems in the economy and society. Such a research perspective is particularly suggested by the fact that in modern societies, subsystems are becoming more closely linked to each other, as specific functions are no longer the domain of specialised subsystems only, but are increasingly also performed by other subsystems.[45] How, then, is the production system influenced by the fact that companies' competitiveness to a great extent depends upon incremental innovations emerging directly from learning processes in production processes? And what are the consequences for the education system when the improvement of skills and competencies is taking place increasingly through processes of learning by interacting at the workplace. At the same time, we have to analyse the organisational preconditions that allow continuous learning on the job and the production of incremental innovations.

We also have to take into account that costs and benefits related to innovation may be distributed unequally and that this may affect the ability to innovate and adapt to changes in a negative way. Those individuals or groups that only register the costs and negative aspects of change will probably develop negative attitudes towards innovations and be strongly opposed to change (Lundvall and Archibugi 2001). To avoid opposition to change, a more equal distribution of costs and benefits related to innovation is needed. Such a holistic perspective needs to be reflected in innovation policy; it emphasises the importance of the coordination of various policy areas, including labour market and social policy.

The bridging function of KIBS firms in the innovation system

We have mentioned earlier that there is no direct link between science and innovation; instead, it is a very ramified relationship. Therefore, a huge national knowledge base does not necessarily guarantee intensive innovation activities at

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[45] Of course, due to this new development, it becomes more difficult to draw clear boundaries between various subsystems in the economy and society.

the firm level. Instead, the *distribution power* within national innovation systems is important. It is, as den Hertog and Bilderbeck argue, "not simply the creation of knowledge that counts but the flow of such knowledge from the producer to the user (and vice versa)" (2000, 223). The role that processes of distributing knowledge have for the innovativeness and competitiveness of companies, the authors continue arguing, is widely underestimated.

In recent years, national but also regional governments have done a lot to improve the distribution power of their national innovation systems. They have set up technology transfer institutes, science or technology parks, and centres of expertise. Universities have improved their transfer capacity by establishing new units to effectively spread the results of their research institutes to potential users. Companies, on the other hand, have started to improve their absorptive capacity by investing in R&D and in technology monitoring.

Particularly, technology-based KIBS firms can have a very active role in the knowledge distribution process, taking up a *bridging function* between knowledge suppliers, on the one hand, and potential knowledge users on the other (Strambach 1997). Such an intermediary role can combine two aspects, " [...] either to translate users' problems into solutions in terms of knowledge or technology, to match users with the appropriate technology available, or to increase awareness of the benefits of the use of certain technologies" (den Hertog and Bilderbeek 2000, 227). Firms making use of such KIBS firms' products can expect additional indirect effects, such as earlier recognition of problems and more rapid adjustment to current economic and structural change, for example (Strambach 1997, 35). In Finland, only very few KIBS firms link university science with business firms. There are some R&D laboratories that have taken up this bridging function, but generally speaking, manufacturing firms seem to have stronger links to universities directly than, for instance, engineering KIBS firms do. The bridging function of KIBS firms in Finland seem to be more horizontal, linking firms with and across industries (Leiponen 2001).

There is, as den Hertog and Bilderbeek (2000) argue, *a new 'secondary' knowledge infrastructur*e emerging together with the growing role of KIBS firms. It combines private and public agents generating and increasingly also distributing knowledge. This means that, with regard to knowledge transfer, boundaries between the public and private spheres are blurring. KIBS firms will become an important actor in this second knowledge infrastructure, partly taking over the intermediary role of public knowledge producers in the first knowledge sector, among them technology transfer institutes and technology parks.

KIBS firms will increasingly form networks with public institutions to jointly generate and, even more importantly, distribute knowledge. The fact that boundaries between private and public realms get blurred may lead to new forms of cooperation, in which experts from KIBS firms will cooperate and solve problems with experts from public KIBS organisations[46]. On the other hand, we may see

[46] Taking the function of public transfer institutions and similar institutions into account, we can call them public KIBS organisations.

increasing competition between private and public KIBS, as they undertake similar tasks and overlap in their functions. There are very few signs that this new 'secondary' knowledge infrastructure is about to emerge in Finland. Only very few partnerships and networks between public and private KIBS exist.

How this so-called second knowledge infrastructure will develop and what concrete role KIBS firms will assume still remains an open question. There is a need to better understand the problem of knowledge diffusion in innovation systems. How can KIBS firms contribute to this function, what kind of cooperation and network formation will take place, and what skills and competencies are needed in KIBS firms to efficiently contribute to the knowledge diffusion function?

National, sectoral and regional innovation systems

One of the main arguments of the system approach is that significant technological change is generally brought about as a result of specific regimes designed to serve specific purposes. These regimes can be influenced by three factors: *geographical scale, technology, and industrial sector.* It is, however, often the case that the three dimensions are conflated. The notion 'national' has been criticised for being too broad, as the institutional structures supporting innovations in one field may not be relevant for other fields; there may be hardly any overlapping between the institutional settings of two fields of technology (Nelson and Rosenberg 1993). The concept of technological systems, however, is broader than the narrow engineering characteristics of products (Edquist 1997). Therefore, as Carlsson and Stankiewicz (1995) argue, *technical systems* can best be analysed in sector analysis.

Nelson (1993) also argues that a significant influence on innovation systems comes from sectoral factors (see also Pavitt 1984). If we refer to the narrowly defined innovation system, the dynamics of the sector is important. "But if one broadens the focus," Nelson continues to argue, "the factors that make for commonality within a country come strongly into view, and these largely define the factors that make for communality across sectors within a country" (1993, 518).

However, technical systems and national systems should not be seen as being alternatives in the sense that only one of the two can be applicable; instead, both technology-specific and nation-specific factors shape the innovation process. Differences in national innovation systems cannot be explained by different production methods but by the relative strength and weakness in different industries (Archibugi and Michie 1997). That is why Whitley speaks about the dominant business recipe or the dominant business system (1992). His argument is that the business system of the dominant sector determines the innovation system of a country to a great extent.

Most innovation system research is defined on a geographical scale. And innovation systems were initially characterised as national in scope, reflecting the

climate of the mid-1980s, which has been characterised by Nelson and Rosenberg as 'techno-nationalism' (1993, 3). The national system of innovation approach assumes that in each country there are specific organisations and institutions that provide security for the production and innovation activities of companies.

Some scholars argue, however, that due to increasing globalisation of technological and other industrial and economic processes, the importance of nation-specific factors in processes of technological development is diminishing (Humbert 1993). Ohmae (1990), for example, claims that in an interlinked economy, the national frontiers are 'melting away'. The nation-state becomes rapidly obsolete as traditional national borders of innovation systems almost disappear. Ohmae maintains that nation-states are losing their power and influence both 'upwards' and 'downwards' to trans-national institutions and organisations, on the one hand, and regional actors on the other hand. Concerning the geographical dimension, we can identify two new trends: innovation processes, which become increasingly *trans-national,* on the one hand, and the emergence of *regional or local networks of firms* on the other hand.

Techno-globalism and techno-nationalism, however, seem to be less exclusive than is often assumed, and much more intertwined. There is no doubt that cooperation in innovation processes becomes trans-national to a growing extent. Governments cannot be seen as exclusively national agents, as they have to adapt to the pressures of global factors and start to opt for cooperation strategies. Multinationals, on the other hand, although increasingly involved in cross-border knowledge exchange, cannot be considered as stateless, as we have mentioned before (Archibugi and Michie 1997).

Porter has forcefully argued against the disappearance of national borders and the diminishing influence of national innovation systems. According to him, differences in national economic structures, values, cultures, institutions, and histories contribute profoundly to competitive success. Globalisation of competition, he continues to argue, seems to make the nation more, instead of less, important. "With fewer impediments to trade to shelter uncompetitive domestic firms and industries, the home nation takes on growing significance because it is the source of the skills and technology that underpin competitive advantage" (1990, 19).

No doubt, there are great differences among various national systems in such attributes as the institutional set-up, investments in R&D, or innovation output, as comparative studies have shown. These national differences have influenced the innovativeness of various countries significantly (Freeman 1997). In addition, most public policies influencing innovation activities are still designed and implemented at the national level. In almost all policy domains, *the nation-state is still the legal entity* (Lundvall 1998, 413). The importance of the national level has to do with the fact that the resources and power to conduct various kinds of policies, whether we look at economic policy, industrial and technology policy, labour market and social policy, or education policy, are attached to the nation-state.

Lundvall (1993) has added another argument. He points out that if we apply a more realistic assumption about microeconomic behaviour which introduces

uncertainty, localised learning and bounded rationality, as key elements of innovation activities, then local and national variations are most likely to result in different paths of techno-economic development.

Lately the regional[47] and local levels (Saxenian 1991; Scott 1991; Grabher 1993; OECD 2000d) of innovation systems have been emphasised. The interest in regional innovation systems can simply be explained by the fact that there are manifest differences in economic growth and social welfare among regions. Actually, regional differences have even increased along with the trend towards a global economy (Fagerberg and Verspagen 1996).

Regions have the advantage of being able to specialise more easily, as they represent genuine communities of economic interest and can take advantage of true linkages and synergies (economies of scale and agglomeration) among economic actors, as coordination at the regional level is less demanding (Ohmae 1990). Kennedy similarly argues that, together with the rise of global corporations, the nation-state is becoming increasingly anachronistic, while the region is becoming the 'natural' area of economic activities (1993, 123).

There is no doubt that the national frame contains more diversity of knowledge favouring cumulative learning processes, "but this will not lead to innovation if there is not enough proximity to support communication" (Gregersen and Johnson 1997, 482). Context-specific sticky knowledge, typical of innovation processes, is best transmitted through frequent and repeated direct interaction. Like tacit knowledge, this kind of explicit knowledge cannot be transferred across time and space independently from the 'knowing subject'. Instead, it needs face-to-face contacts (Lam 1999). "Geographical proximity in transmitting matters, because it is inherently non-rival in nature, and knowledge developed for any particular application can easily spill over and have economic value in different applications" (Meeus and Oerlemans 1999, 140).

Some scholars refer to *social capital* as the key advantage of regional economies. As local production systems and local innovation milieus are better suited to accumulate large stocks of social capital, exchange of sticky knowledge in interactive learning processes can best take place in regional innovation systems. Regions with high levels of social capital obtain, according to Putnam (1993), manifold economic benefits, including high rates of technological innovations.

The regional level becomes particularly crucial when analysing radical, transformative innovations. Then communication and knowledge exchange is increasingly difficult as codes developed to communicate a constant, or a gradually changing, technology is becoming inadequate. On the one hand, producers having

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[47] Regions are here understood as sub-national entities. Four criteria are often used to define a region: (1) a region must not have a limited size; (2) it should display homogeneity in terms of specific criteria; (3) it may be distinguished from bordering areas by a particular kind of association of related features; and (4) it must possess some kind of internal cohesion (see Cooke and Schienstock (2001).

followed a given technological trajectory will have difficulties in evaluating the potentials of the new paradigm. Users, on the other hand, will have difficulties in decoding the communications coming from producers, developing new products built according to the new paradigm. "The lack of standardised criteria for sorting out what is the best paradigm implies that subjective elements in the user/producer relationships – like mutual trust and even personal friendship become important. These subjective elements are not easily shared across regional borders" (Meeus and Oerlemans 1999, 149).

The quarrel over whether the national, the regional, or the trans-national level plays a more dominant role in shaping innovation processes is fruitless. The importance of these levels may vary from case to case. The space in which technological change develops may be regional, national, or global, but it is more likely that it involves a complex and evolving integration at all three levels (Archibugi and Michie 1997).

Meyer-Kramer (2001) argues that the region represents the best platform for evaluating social experiments which are interesting from the viewpoint of industrial innovation. These experiments are often very complex and need close cooperation among different actors, which can be achieved most easily on the regional level. An eco-industrial park, for example, represents such a complex experiment, in which a community of businesses seeks to enhance their environmental and economic performance through collaboration in managing environmental and resource issues.

The national level is the appropriate area in which to establish more general framework conditions. The polytechnic reform in Finland, for example, can be seen as a major change in the framework conditions as it aimed at meeting the demand for more practice-oriented higher education. And the Centre of Expertise Programme was established to stimulate economic development on the regional level.

On the trans-national level, institutions are necessary to achieve effective international consultation and cooperation harmonising framework conditions. An agreement on minimum social standards, for example, can be seen as an important task which needs to be dealt with at the international level. Also, new economic incentives to reduce environmental damages can only function effectively if they are introduced on the basis of international agreements.

While it is generally accepted that innovation systems can develop at levels other than the national one, research has rarely been conducted *to understand the relationships among the various levels*. Research should be more concerned with the questions in which way the various systems interact with each other, what kind of exchange takes place among them, and how institutional settings can be optimised in various systems to reduce functional overlapping.

From path dependency to path creation

Output specialisation, accumulation of knowledge and 'lock-in'

Innovation systems in general have *different output structures*; they produce different kinds of knowledge. This can be described as a pattern of *national specialisation or of output asymmetry*. Specialisation processes can partly be explained by differences in natural endowments: countries develop specific knowledge to exploit their national resources. However, as production becomes more knowledge-based, advantages like a developed research infrastructure, a highly qualified workforce, or an innovative milieu are becoming more important factors than natural resources for companies' investment strategies. This means that a supportive environment for innovation activities can be deliberately created. Output asymmetry, therefore, is largely related to *constructed national advantages* (Saviotti 1997, 180). To make a space attractive to foreign investments but also to keep local companies in the territory, governments can establish specific organisations and institutions to support their innovation strategies.

Furthermore, today's advantages lay the foundation for succeeding rounds of progress (Foray 1997, 65). This means that knowledge generation is *cumulative and integrative*; the extent to which new knowledge is created depends upon the knowledge already accumulated within an innovation system. In other words, knowledge generation produces 'positive externalities'; the more a specific kind of knowledge has been produced and is embodied in technologies, organisation forms, institutions, and human resources, the easier it becomes to produce even more related knowledge. Here we can talk about the *'increasing returns' logic* (Arthur 1996).

Accumulation of technical knowledge, according to Dosi (1982), leads to the formation of a path of possible technical developments, which delimits the options for further development. The cumulative nature of the process involves the narrowing of the range of potential choices as the evolution of the technology proceeds. In this respect, we can speak of *path dependency* (David 1985). Path dependency embodies strong prescriptions about which direction of technological change should be pursued and which should be neglected.

Dosi's differentiation between a general technological paradigm and various national trajectories underlines the argument that technological development is not driven by a single scientific or technological logic but that there is room for social structures and social choices to shape its direction. While the cumulative nature of the process of technological development narrows down the range of potential choices, *national trajectories* increase differentiation and diversification as offshoots from the main development path (OECD 1992).

The concept of technological trajectories has been criticised for applying a perspective of technical determinism. To avoid such a reductionist perspective, Perez uses the expression 'techno-economic paradigm' (1983). This indicates that

the changes involved go beyond engineering trajectories for specific product or process technologies. The unfolding of a new technological paradigm can, as Perez argues, only take place together with fundamental institutional, managerial, and cultural changes. Taking up this argument, we have to consider — parallel to the notion of technological trajectories, "the development of different organisational trajectories, namely specific arrangements of systems of means oriented towards increasing productivity and competitiveness in the new technological paradigm and in the global economy" (Castells 1997, 153). Since technical and organisational structures co-evolve, we suggest *speaking of national trajectories of techno-organisational paradigms* (Schienstock 1997).

The path creation perspective

The strength of the path dependency concept lies in the fact that it does not separate innovation from past developments but assumes some kind of *continuity* in the process of technical change. Innovation lines up with earlier changes, which means that it has historical antecedents of novelty. "[...] the dynamic process itself takes on an essentially historical character" (David 1985, 332). There is, however, always the *risk that path dependency turns into so-called 'lock-ins*' (Grabher 1993; Johnson 1992; Schienstock 1997). A 'lock-in' exists when a specific development path in an economy exhausts itself, indicated by a loss of competitiveness, retarding economic growth, and increasing unemployment.

The lock-in phenomenon suggests giving more attention to the problem of *path creation*, an aspect that has been less researched so far (Garud and Karnoe 2000). But Schumpeter, when writing on the process of creative destruction (1942), already stressed that innovation implies breaking out of the traditional path of technological development. He *saw the will of the entrepreneur* as decisive for the creation of a new development path. The path-creation perspective thus differs from the path dependency perspective in the way in which economic actors are perceived. Rather then treating them as passive observers within a stream of events, they are seen as *knowledgeable agents* with a capacity to reflect and act in ways other than those prescribed by the existing social rules and taken-for-granted technological artefacts (Garud and Karnoe 2000, 235). Path creation is seen as a process of mindful deviation; it implies dis-embedding from the structures that embed economic actors.

Garud and Karnoe (2000), analysing processes of path creation following Schumpeter, stress the important role of the entrepreneur in this process. Path creation, as the two authors argue, "provides a way of understanding how entrepreneurs escape 'lock-in' " (ibid., 238). They interpret path creation as a process of transforming a technological field in which different actors with different frames are cooperating. A main part of the transformation process is the re-negotiation of meanings of objects and practices constituting the field. In this process, the entrepreneur plays a key role as a stimulator, coordinator, and enabler. Over time, these new meanings and practices will be taken for granted and direct

the actors in their behaviour. Entrepreneurs then become embedded in self-reinforcing processes of a technological field that they have helped transform.

There is no doubt that entrepreneurs have a key role to play in processes of creating and diffusing a new paths of techno-economic development. But a theory on what produces deflections from a development path and how this takes place needs to be much more complex. Besides entrepreneurship, there are many other forces that contribute to the unlocking of the existing and the creation of new development paths, such as new technological paradigms, heterogeneity among agents, the co-evolutionary nature of socio-economic adaptation, and the invasion of new organisational forms from other contexts, for example. It is also important to differentiate between the *'human will'* and *'change events'* as influencing factors.

Freeman (1997) argues that the deflection from a development path and the diffusion of a new techno-economic paradigm is a trial-and-error process involving a great institutional variety. Perez (1983) has pointed out that fundamental technological novelties can only become transformative together with organisational and institutional changes. It is likely that the social and institutional framework, which is hospitable to one set of technologies, will not be suitable for a radically new technology. Whereas incremental innovations can be easily accommodated, this may not be the case with radical innovations, which by definition involve an element of creative destruction. Instead, the problem of structural and social adjustment can be very great.

This is quite obvious when we consider that a new fundamental, path-creating innovation requires the development and coordination of a vast array of complementary tangible and intangible elements: new management techniques, new organisation forms, new kind of workforce skills, and new habits of mind and patterns of taste. But many other types of institutional changes are also called for as in standards, patents, new services, new infrastructure, government policies and public organisations (David 2000; Freeman 1997).

Sabel (1994, see also Schienstock 1996) has characterised path creation processes as 'bootstrapping reforms', also stressing the importance of trial and error. He argues that stable and lasting processes of path creation and diffusion can only emerge if all actors of an innovation system are marching in steps, monitoring each other's change processes and adapting to them. But it is beyond the capacity of the social actors to come to terms on the future techno-economic structure, simply because it is unknown. What they can do, however, is to continuously reflect on the previous change processes and, in the light of their experiences, make corrections, if needed. Continuous exchange of information and knowledge in dialogues and multilogues is needed to stabilise a new development path. Sabel concedes the government a key role in the path creation process. However, path creation also needs new *forms of coordinating* various innovation activities; here we suggest *vision creation* and *discursive coordination* as key elements of the new steering form of the transformation process.[48]

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[48] In Chapter Three, we have explained both aspects in more detail, referring to Finland as an example.

Conclusion

The system of innovation approach represents a paradigm shift in the way we interpret the relationship between research, innovation, and socio-economic development, giving up the attempt to understand successful innovation through single-factor explanations. The approach has the potential to transcend the linear view of technical change, as it recognises the importance of collaborative knowledge production and use among firms and with other organisations.

As a rather new concept, the innovation system approach is associated with various kinds of ambiguities and unresolved problems. What to include in the system, who the key actors are, and where to draw the boundaries of a system are still unresolved problems. A functional analysis, we have argued, can partly overcome these problems; it provides a good basis for comparative analysis and for studying organisational diversity among innovation systems.

Although there is widespread agreement that the relationships among actors are the most important characteristics of an innovation system, the scientific debate has not paid much attention on how to co-ordinate innovation activities most efficiently. More attention, we have argued, must be given to the aspect of governance in innovation systems and the impact of social capital on the development of various forms of governance.

Innovation systems were initially characterised as national in scope. However, serious doubts have been expressed about whether the nation is the adequate level to employ in analysing innovation processes and their institutional embeddedness. While there is no doubt that in many cases the regional level matters and that in other cases the trans-national level becomes crucially important, discussion about the predominance of one of the three levels is fruitless. Instead, research has to focus on the interaction between the three levels. How much autonomy is needed for lower-level systems to function efficiently and how can lower-level innovation systems contribute to the functioning of higher level systems?

We have also identified new emerging research perspectives and questions. So far, the focus of the innovation system approach is on the endogenous dimension, while little research has been done on the exogenous dimension. This is due to the fact that the innovation system is rarely analysed as a subsystem of the wider economic system and as a part of society. What is the function of the innovation system in the economy and in society? Related to this perspective is the question of how the innovation system is linked to other parts of the economy and society. How does the innovation system interact with other economic and social subsystems, what kind of links exist with the legal or the education systems, for example, and how do these subsystems mutually influence each other? It is of particular relevance to understand what kind of benefits and costs an innovation system produces, how these are distributed and how the distribution affects the system's capability to learn and innovate.

We have stressed the need to better understand the role of KIBS firms in the innovation system, particularly when the emphasis is on knowledge distribution. What is the extent to which KIBS firms compete with public knowledge-distributing agents, and how can cooperation be organised to increase the distribution power of innovation systems?

Path dependency has been mentioned as an important aspect of innovation and learning. However, while path dependency may support adaptive learning, it may actually hinder innovative or reflexive learning and lead to lock-in situations. In the current situation of rapid socio-economic transition, it may be useful to focus more on the problem of path unlocking and path creation than on path dependency.

6 INNOVATION PROCESSES IN LOW-TECH, HIGH-TECH, AND SERVICE INDUSTRIES

The view that innovation and technological change are associated only with high-tech industries is widespread. However, innovation and learning are a ubiquitous phenomenon, taking place in high-tech and low-tech industries as well as in services. This does not imply that we can find the same pattern of innovation activities in all industries and sectors; in fact, the character of innovation and learning, as we have mentioned above, often differs significantly with respect to industrial sectors. To be able to stimulate and support innovation processes, a better understanding of different modes, particularities, and specific problems in various sectors is needed. In the following chapter, we will briefly discuss the concept of high-tech industries and the problems related to this concept. Next, we will analyse different innovation patterns in high-tech industries, low-tech industries, and in KIBS firms. In the end, we will deal with the problem of trans-sectoral cooperation.

From high-tech to knowledge-based industries

The share of high-tech manufacturing industries (aerospace, computers, electronics, and pharmaceuticals) has traditionally been used to estimate the importance of technology-based activities within an economy (OECD 1999). The criterion commonly used is the ratio of R&D expenditure to total sales.[49] The major flaw in

[49] In high-tech industries R&D spending amounts to more than 4 percent of turnover, while industries with R&D expenditure of less than 1 percent of the total turnover are classified as low-tech. Industries spending 1-3.9 percent are classified as medium high-tech and medium low-tech industries.

this measure is the fact that it is based on a one-sided fixation on R&D intensity as an indicator for levels of technology and knowledge across industries. One aspect is that a more or less linear dependence of the level of technology and knowledge on R&D intensity is assumed, ignoring a whole range of other types of knowledge-creating processes (Palmberg 2001).

Furthermore, the measure only focuses on the producers of technology but not on the users. It therefore reveals nothing about the qualitative differences in the nature of innovation processes in various industries and about different socio-economic impacts of innovation output. We may get an overly pessimistic view of the nature and the potential of innovation and industrial change in the sectors (including services) in which in-house R&D activities are less important, while the importance of R&D-intensive industries might become overemphasised (Palmberg 2001).

The economic growth of a country might be more affected by the extent to which knowledge and modern ICT is used within the whole economy than by the share of high-tech producers. So-called low-tech industries see significant productivity increases due to the fact that they become intensive users of modern ICT and increasingly adopt technology-intensive production techniques. In the traditional sense, their products are not seen as high-tech but their production processes become more technology-based.

The tendency towards growing knowledge intensity is not restricted to manufacturing only; it also applies to services (OECD 2000b). This is partly related to the fact that the service sector is developing into an important user of modern ICTs. For example, the use of modern ICTs is pervasive in communications, finance, insurance, and business services. But KIBS firms also become important producers of ICT, as software and contents are becoming more and more important.

Value creation and innovation processes in different industrial sectors

In the following, we assume R&D intensity to be one, but not the only, important aspect that differentiates innovation activities in various industrial sectors. R&D intensity might be associated with other types of innovation-related activities, which have to be highlighted in order to get a better picture of complementary competencies, restructuring practices, and required institutional support. To better understand the innovation potential of various industrial sectors, we analyse separately the specific paths of value creation and innovation in high-tech and

low-tech industries as well as services separately.[50] While in high-tech and low-tech industries innovation patterns in Finland do not differ significantly from international trends, the situation is quite different when we refer to KIBS firms. Due to the fact that Finnish KIBS firms are in general rather small and regionally oriented, innovation patterns in Finnish KIBS differ significantly from those of large, international-oriented KIBS firms. In the following, we will elaborate these differences.

Innovation in high-tech industries

High-tech industries are characterised by the prevalence of generic knowledge bases, greater reliance on scientific knowledge and new technologies, and closer ties to universities and research institutes. The nature of contracts between universities' research laboratories and high-tech science-based firms, however, shows new tendencies. The traditional motive of companies to set up contracts with research laboratories was to purchase knowledge produced by them. Companies have developed research capacity to be able to absorb basic scientific knowledge. But as changes in the nature of research contracts have occured, the aim of developing research capacity has also changed – it is now to *stimulate a process of joint creation of more fundamental knowledge*, which is less directly applicable by other firms. The new form of contracts can be seen more as a subsidy of the firm to the laboratory, which gives firms the right of access to the laboratory's network rather than an agreement on the delivery of specific services (Cohendet and Joly 2001).

While companies may benefit from this 'unified type of research' by acquiring new patents and methods, which are important in high-tech industries, a main aspect of the new relationship between research laboratories and industry is the *exchange of tacit forms of knowledge*, as companies have access to yet unpublished papers. And there is another aspect involved in the 'unified type of research'. Becoming a co-author of a scientific paper signals tacit knowledge and other not publishable resources. The more members of a company publish in scientific journals, the more credibility they develop, making the company attractive as a partner in knowledge exchange (Meyer-Kramer 1998).

As the nature of contracts between firms and laboratories changes, *the development of 'finalised' basic research*, strongly supported by private funds, becomes a growing phenomenon. One may see some risks that basic research is becoming more dependent upon industry support and such support may have increasing influence on the construction and selection of scientific themes. There

[50] Our attempt to identify some general trends in value creation of the three types of industries does not exclude specific development trends in individual industries or even individual companies.

is fear that the increasing cooperation between universities and industry may reduce cooperation within universities, and in the end, lead to a possible fragmentation of knowledge (Cohendet and Joly 2001).

The emergence of *new science-based firms in high-tech fields* closely linked to universities is also a rather new phenomenon. Small start-up firms have become key actors in innovation processes in high-tech industries. Pavitt (2000b) argues that the reason for the development of new science-based firms is not a changing incentive structure in universities. Instead, he sees increasing opportunities for practical exploitation in a variety of different fields, such as molecular biology, software-related fields, nano-technology, and combinatory chemistry, as the main causal factor. Compared with large established firms, small start-up firms have the advantage of being more flexible and more specialised, which helps them to adapt more quickly to new developments and to take up any new opportunity related to the new emerging knowledge (OECD 1998a).

In the emerging areas where market and technical risks are large, *new forms of cooperation develop between small start-up firms and large firms with multiple technological capacities*. While the small firms become pioneers on new frontiers, large companies are exploring possible advantages of getting involved in the new technological fields. Large companies, trying to avoid the technical and commercial risks associated with exploring new technological opportunities, see increasing advantages in cooperating with small start-ups. They set up contracts with them to explore specific fields of technological opportunities. This gives small companies greater possibilities to explore the innovation potential of new knowledge and technical concepts and helps larger companies to monitor technological change without taking high financial risks. Another advantage is that large companies do not need to commit themselves to long-term projects associated with in-house development, the reversing of which may become very difficult. The consequence is that traditionally direct links between large multi-technology firms and university-based research are increasingly *mediated through universities-based spin-offs* (Pavitt 2000b).

The *internationalisation of basic research* is the third development that characterises innovation processes in high-tech industries. Larger companies have learned how to join foreign networks and to benefit from foreign basic research. Benefiting from the possibilities offered by modern ICTs, they set priorities to invest resources in some leading edge locations where they find the best conditions for excellent research (Meyer-Kramer 1998). The trend of cooperating internationally with universities and research institutes and of establishing one's own research capacity close to 'centres of excellence' reflects the growing pressure on firms to keep up with the latest advancements in basic research, wherever they have been developed. This is particularly the case for large companies in small countries, where the basic research competencies are often rather limited.

While cooperation between industry and science has a long history, the forms of cooperation have changed. Traditionally companies concentrated on knowledge exploitation, keeping some R&D capacity enabling them to absorb and transform

the knowledge they purchased from scientific institutes. New cooperation practices aim at stimulating a process of jointly creating more fundamental knowledge that is less directly applicable by other firms. In addition, small university-based spin-off firms become pioneers on new scientific frontiers, while large companies trying to avoid the technical and commercial risks of innovation processes seek close cooperation with them. Furthermore, global innovation competition forces companies to prioritise some leading edge locations where they find the best conditions for excellent research.

Value creation in low-tech industries[51]

In general, companies in *low-tech industries do invest less intensively in R&D*. As these are mature industries, technological opportunities may be limited. Products are of the low-complexity type and their technological development processes may be characterised as more or less incremental. Imitation of products is quite easy, which does not make patenting a viable option. Thus companies have to develop other strategies of safeguarding their returns on investment.

One option is to *concentrate on specific niche markets* and to acquire a leading position through mergers and acquisitions. Furthermore, to compensate for low R&D investment, companies can apply a variety of complementary activities that constitute the main source of value creation. A key strategy is to continuously *invest in production technology* to increase the efficiency of production, to integrate production to an even greater extent, thereby reducing costs and giving them a temporary advantage in price competition. Companies increasingly extend their technological restructuring to their supply chain in order to further raise productivity, installing among others 'Just-in-Time Systems'. The development of production technology, including continuous improvement of the system in use, often triggers *incremental product innovations*.

Strategies aiming at increased productivity are mostly accompanied by *extensive market-related business activities*. These include: the development of close partnerships with customers in order to quickly adapt to market changes; improved product design to meet the tastes of various customer groups; nurturing a strong brand name; and targeted marketing activities to secure customer loyalty. All these practices can become access barriers for newcomers, since entering the market successfully implies more than just imitating low-tech products; it also includes disposing of competencies to effectively carry out the above mentioned business functions.

To effectively control complex technological production systems, workers depend to a great extent upon *practical or tacit knowledge accumulated in processes of learning by using* rather than codified or theoretical knowledge. These learning processes include additional incremental innovations, as the introduction and use

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[51] This chapter relies heavily on the report written by Palmberg (2001).

of new technologies is often associated with solving relatively complex but practical engineering problems. We can speak of a process of further development or re-invention. Developing efficient technological practices also involves modest levels of formal R&D, but even then copying is extremely difficult, since tacit knowledge predominates.

Low R&D investment does not mean that *opportunities for technological development* do not exist. However, they are mainly related to *the use of knowledge created in other industries or scientific labs*, as is the case, for example, when new materials are applied. This means that low-tech companies concentrate *on exploitation of existing technological knowledge instead of exploring new knowledge* (Palmberg 2001). Exploration, however, may take place with respect to *social innovations* including the intelligent use of modern technologies, new organisation forms, and new marketing strategies.

In order to be able to exploit the existing technological knowledge, low-tech companies have to develop close relationships with knowledge-creating organisations including universities, but even more with polytechnics. And they have to participate in various networks with a variety of different industrial actors. Of particular importance for low-tech firms is the *cooperation with KIBS firms*, since by assuming a bridging function, the latter contribute significantly to the dissemination of practical knowledge in applying, embedding, and controlling complex technologies effectively as well as in developing and applying effective marketing strategies.

In order to be able to cooperate in innovation networks and to make optimal use of external knowledge low-tech companies have to develop *absorptive and transformative capabilities.* Companies' innovative capacity to a great extent depends upon their capability to integrate external knowledge and new technologies developed elsewhere with their own knowledge and technologies. Their absorptive capacity, however, is more linked with continuous knowledge accumulation through learning by using and direct problem solving rather than with major internal R&D activities. There is a *risk* that a low commitment to R&D activities might cause *problems in case of radical technological shifts*, as companies will not be able to understand and cope with such a situation properly.

Low-tech companies, we can conclude, although characterised by being less R&D-intensive, are nevertheless engaged in rather complex internal knowledge creation processes. They focus on knowledge exploitation developed elsewhere, but they also depend on knowledge developed in-house in an incremental fashion and on complementary design and market activities. They become intensive users of new technologies aiming to increase productivity. Process innovations are dominating among low-tech companies but these often trigger more or less incremental product innovations. Participation in innovation networks is quite common, and to be able to gain from knowledge flows within these networks, low-tech companies have to develop absorptive and transformative capacity, which to some extent also include a lower level of R&D activities. But a low level of R&D intensity contains some risks and can become a problem in case of rapid technological change.

KIBS firms and innovation processes [52]

There is some evidence that many service firms are relative laggards in terms of technological innovation in Finland as well. Also, the share of R&D in the service sector is still below the sector's share of economic output and employment (Leiponen 2000). To some extent, this can be related to *specific features of services*: their intangible products, which make storage and transportation very difficult, direct interaction with consumers, and knowledge intensity, to mention a few. However, as services increasingly adopt modern ICTs, they become more like manufacturing (Miles 1999). This means that *service-specific barriers to innovation are about to disappear*. Of course, the service sector is very diverse. Investment in R&D is concentrated mainly in knowledge-intensive business services firms (KIBS) (Leiponen 2000 for Finland; Hauknes 1996).

KIBS firms' *innovations are typically linked to satisfying client-specific demands,* but KIBS firms also introduce innovations themselves. However, KIBS firms in Finland seem to be less aware of the economic potential innovations can provide in order to develop the firm and make it more competitive. Successful development and improvement of services receives systematic and frequent thought only in a minority of firms. Quite many companies emphasise improvement of individual skills instead of focusing on developing organisationally embedded and replicable solutions to predefined services problems. This occurs, although firms profit more from innovations in which new knowledge becomes embedded in service solutions or packages that can be improved cumulatively (Leiponen 2001).

As innovation processes in KIBS often involve small and incremental changes in processes and procedures only, intensive R&D is not always required. In the literature, particular emphasis is placed on the informal nature and organisation of service innovation processes. Even highly innovative firms do not often have an R&D department. Finnish KIBS firms are only beginning to develop more systematic processes and organisational structures for developing new products and enhancing organisational capacities. R&D or product development teams are mostly temporary, even if the search for new ideas takes place systematically and continuously. Some companies have experimented with more permanent quality or development teams, but they had to give them up due to the inability of the members of such teams to remain up-to-date on developments related to customers and markets (Leiponen 2001).

A lot of service development in Finnish KIBS firms is carried out in team- or department-level training and brainstorming meetings. Employees invest some time in such development meetings, which also include some training elements. This indicates the more unsystematic and ad-hoc character of service innovation processes in KIBS firms. Besides learning in development meetings and brainstorming sessions, learning on the job in service relationships with clients is also important. Moreover, investment in in-house training is often very significant.

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[52] This chapter relies heavily on the report written by Leiponen (2001).

Service firms in general rely to a very limited extent on universities and research laboratories for the knowledge they require (OECD 2000b, 144); also, some KIBS firms do not invest intensively in formal R&D: their R&D expenditures often capture only a small part of their total innovation effort. By far the most important source of service innovation ideas is the customer. Very weak linkages between KIBS firms and academic experts are particularly common in fields such as management consulting and advertising services. This is due to the fact that in such cases, KIBS firms are mainly interested in the development and marketing of new ideas such as new restructuring strategies. But it is important to capture a more colourful picture of KIBS firms' activities. Particularly technology-based KIBS firms invest heavily in R&D; progress in specific fields of software, for example, makes large investments in R&D necessary and such progress is closely linked to university research. While in general co-development with technology suppliers is typical for innovation processes in services, which distinguishes it from innovation processes in manufacturing, this seems to hold less true for KIBS firms' innovation processes.

KIBS firms use ICT very intensively. Due to the fact that they are information- and communication-intensive, KIBS firms more than other service firms, are dependent on advances in modern ICTs, which allow them to intensify information exchange. Also, the move into knowledge technologies has expanded the scope for ICT use in KIBS firms. But thus far Finnish KIBS firms perceive ICT more as a factor that improves internal processes and productivity than as a source of innovation, with the exception of technology-based companies. They also use modern ICT as communication technology quite extensively.

While services in general are characterised as less skilled, KIBS firms rely heavily upon professional knowledge; they have a strong focus on scientific and ICT skills (Leiponen 2000 for Finland; OECD 2000b, 143). Thus their employment structures are heavily weighted towards scientists, engineers, and experts of all types (Miles 1999). But the quality of services provided by firms also depends on various skills of service workers, including creativity, resourcefulness, the ability to cooperate, and strategic thinking. In addition, tacit knowledge and experience with customers are needed to restructure businesses and to develop new services (OECD 2000b, 147).

KIBS firms in Finland seem to pay less attention to knowledge sharing within the organisation. Many firms do not systematically collect lessons learned and client evaluation from the past either. This means that organisational and cumulative learning rarely takes place, which is very important in order to create increasing returns. KIBS firms seem to benefit more from individual skills and competencies than from knowledge embedded in collective practices.

To protect their innovations and appropriate the returns on their activities, service companies seldom rely on patents, since these apply primarily to products or manufacturing processes. This can partly be explained by the fact that only

software and some other information services are covered by the patent law, while most service innovations are not. This does not mean that companies do not try to protect their innovations. But, to get protection, service companies rely more on copyrighting, brands, and trade secrets (OECD 2000b). KIBS firms, however, often feel that their core knowledge is so tacit or procedural and embedded in people or the service process that it does not need to be protected. This hinders diffusion of knowledge, as Anderson and Howell (1998) argue, because companies are not forced to give detailed information about their innovations.

The following table attempts to distinguish between the modes of innovation present in high-tech firms, low-tech firms, and KIBS firms.

	Low-tech industries	High-tech industries	KIBS
Competition criterion	price / quality	innovation	customer orientation, innovation
R&D intensity	low	high	high or low
Patenting	low	high	low / copyright
Type of innovation	process innovation	product innovation	new concepts and ICT-based services
Scale of innovation	incremental	fundamental	incremental and fundamental
Type of knowledge	tacit / practical	codified / theoretical	codified and tacit
Type of learning	learning by using	searching and exploring	interactive learning
Cooperation	customer-producer relationships	university-producer relationships	KIBS-client relationships
Skills and competencies	practical knowledge	theoretical knowledge and cognitive skills	theoretical and practical knowledge

Table 5. Innovation modes in low-tech industries, high-tech industries, and knowledge-intensive business services.

Competing paradigms

Above we have argued that innovation is a collaborative undertaking that crosses industrial and institutional borders. Low-tech industries need to develop their absorptive and transformative capacities to be able to adopt knowledge created in high-tech industries. High-tech industries, on the other hand, increasingly cooperate with universities and research institutes to jointly create more basic knowledge. And KIBS firms, being in the business of supplying specialised expertise and knowledge, naturally have to cooperate with a number of different clients.

Of course, cooperation and knowledge exchange are not easy to achieve as they involve actors with different interests, values and cognitive frames. "In particular, the typical pattern of innovation characterised by incremental change and the combination of available technologies and concepts originating from different industries and communities also imply the confrontation of paradigms, heuristics or thought worlds" (Palmberg 2001, 85). Cooperation between universities and high-tech industries may also be hampered by conflicting interests and different cognitive frames, as the latter may think more in terms of 'finalised' basic research than core actors in the science system. The fear that due to collaborative knowledge creation, industry may have an increasing influence on the construction and selection of scientific themes may cause some problems for the cooperation between high-tech firms and universities. And the role of KIBS firms is even more difficult as they often cooperate with a number of clients with very different paradigms, heuristics, or cognitive frames. But exactly because of the difficulties to integrate different paradigms and heuristics KIBS firms are so important as knowledge transfer agents.[53]

Considering the functioning of innovation systems, it becomes crucial that these confrontations and conflicts of interests can be overcome. In order to resolve them, new organisation forms may be needed for encouraging understanding among cooperation partners and to react quicker to changing environments. We can think of inter-organisational project groups, independent of external influences, in which trust can be built and common cognitive frames can be developed. But changes in framework conditions may also be necessary to facilitate conflict solutions. In some cases, it may be necessary to change the competition law to allow more intensive cooperation; in others, property rights may have to be changed to stimulate cooperation. Problems may also occur through regulatory inertia and insufficient standardisation (Palmberg 2001).

Furthermore, to bring companies to abandon traditional behaviour and to turn to more innovative behaviour, cultural changes may be crucially important. For example, the fact that forest industries have been slow in adopting new knowledge from biotechnology has been explained by the widely held traditional world-view

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[53] See also Chapter Four.

in the forest industries. Major cultural changes may be necessary to overcome the problem of low knowledge exchange between low-tech firms, on the one hand, and firms from the high-tech sector or KIBS firms on the other.

KIBS firms may have an important role to play, where cooperation in knowledge creation and co-management in trans-industrial innovation processes is hampered by different paradigms, heuristics, and cognitive frames. However, to successfully fill such a boundary-spanning role, KIBS firms need different forms of knowledge and practices at their disposal. Context-specific scientific knowledge, tacit knowledge, and experiences with customers, problem-solving know-how, creativity, strategic thinking, and regulatory expertise are important as well as the use of interactive learning practices and the mechanisms of consensus building. Whether KIBS firms are able to take up the role of the facilitator of interaction and knowledge exchange among firms from different industries and the mediator between different interests depends to a great extent upon the quality of their human resources, their proper organisational structures, and their internal frames of mind.

7 INTRA-FIRM RESTRUCTURING

It is evident that the nexus of innovation systems is the *individual firm*, as it is there that the final conversion of knowledge into industrial innovation takes place (Hauknes 2000). Therefore, in this chapter the focus is on companies' restructuring strategies aiming at improving their innovation and learning capability. It is widely agreed that companies, by *incorporating modern ICTs* into their production processes, can enhance their innovation capacity significantly. But while modern ICTs have the potential to improve and accelerate companies' innovation processes, they are not innovative themselves. Instead, it is the way in which companies make use of them that matters.

In addition, gains associated with the use of modern ICTs can best be realised when firms *make complementary investments* in their organisational structures, business culture, and human resources. The OECD (1998a) characterises the new emerging organisation form that raises productivity significantly and stimulates innovation processes as a 'high performance workplace model'. Flexibility and experimentation are the two key principles on which the organisational model is based. New ways of organising work to effectively exploit technology, on the one hand, and the building and using of intangible assets, most importantly human resources, on the other, are mentioned as the two distinct sets of features of high performance workplaces. We have to stress, however, that there is *no single static model and firm strategy* that automatically brings benefits (OECD 1998a, 271). But it is possible to identify some general trends of organisational restructuring that support the transformation of knowledge into new products and processes. These include a *technical, organisational, cultural and human resources dimension* (Schienstock 2000a).

We may speak about the emergence of *a new Leitbild representing a new techno-organisational logic*. A Leitbild is defined as a symbolic schema for creating reality (Berger and Luckmann 1967). It can be characterised as a set of general ideas of effective production and business structures. It also has a normative dimension and as such it becomes the basic of practical restructuring processes. It

also allows for diversity, however, as the transformation of a Leitbild into reality can result in different organisational trajectories. Castells (2000) and other scholars understand the *network organisation* as the new restructuring Leitbild in the knowledge economy. In this and the subsequent chapter, we discuss companies' restructuring strategies to improve innovation activities in more detail. In this chapter we deal with intra-organisational restructuring practices, while in the next chapter we focus on external restructuring, paying particular attention to inter-organisational networking.

The paradigm shift in the use of modern ICTs

Modern ICTs have developed dramatically in recent years. The *new applications* that have occurred may have a significant impact on the innovation capability of companies. In this respect, it is helpful to mention the following developments:

- extraordinary improvement of the technical performance of modern ICTs; the speed of communication in particular has increased dramatically, as high volumes of data are moving from one location to another in a very short time;
- a sharp rise in communication bandwidth, with more information of multi-frequencies travelling at the same time down a common line;
- continuous improvement of the price-to-power ratio in information and communication; cheap storage, processing, and transmission capacity is available about everywhere;
- standardisation of microprocessors, communication intersections, system components, and user software, which allow for the compatibility of various technical subsystems in forming a larger platform that can be used by everybody;
- the possibility to combine text, voice, video, data, and/or graphics within a multimedia communication system due to the digitalisation of information (Fulk and deSantis 1995); and
- increasing mobility due to processes of de-materialisation and miniaturisation. Connected ICT devices can be made small enough to be carried around; their use is not limited to certain fixed locations (Lillrank 1996).

Together with a growing technical potential of modern ICTs, a shift has taken place from data-processing (administrative, centralised mainframe computing) and management information systems (MIS) to individual and office-support on PCs and office systems, and then to electronic data interchange (EDI) and inter-organisational systems, organisational 'platforms', and network computing (Ward

et al. 1990). There is, however, no automatic relationship between the improved technical potential and companies' innovation activities. Modern ICTs are *multifunctional technologies* as the table below shows and they can be used for different purposes. It is *the specific use strategy that primarily influences the benefits that can be gained from the application of ICT.*[54]

Metaphor	Function	Aim
tool	support for work processes	increase quality, cope with increased complexity
automation technology	elimination of human labour	costs cutting
control technology	controlling production processes	adjustment to changes, avoiding defects
surveillance mechanism	monitoring work behaviour	increasing work efficiency
information technology	collecting, processing, and creating information	organisational learning
organisation technology	coordination of work processes	integration of processes, organisational flexibility
network technology	technically mediated communication	exchange of information and knowledge

Table 6. Various functions of modern ICT.

In the following, we will focus our attention on the automation, informating and communication function of modern ICT.

Innovation processes are less amenable to automation

As modern ICTs made it technically possible and economically attractive to codify various kinds of knowledge, previously remained in tacit forms, they were traditionally used to *automate operations* and whole production and administration processes. Thus they replace human labour with a technology that enables the same processes to be performed with more preciseness and continuity. As a labour-saving device, modern ICTs do not differ in any way from traditional machines.

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[54] Of course, use practices are not independent of technical dimensions and characteristics.

However, different types of work and decision processes are more or less amenable to routinisation and automation. Since ICT has grown cheaper and more powerful, the number of work processes that can be automated has increased. But even if we take into account advances in artificial intelligence, the *codification of tacit knowledge, and therefore, the potential for ICT to substitute for human work is limited*. Managerial work or professional work, which is more complex and cognitively demanding, has proved less amenable to computerisation. Similarly, tasks that require judgement, creativity, and frequent exceptions have also proved remarkably difficult to automate with modern computers (Bresnahan et al. 1999, 11). *Innovation functions*, we can conclude, are less amenable to automation; they depend to a great extent on human capital and tacit knowledge.

The informating function

The *informating function* of ICT is very important, particularly as far as innovation activities are concerned. Zuboff (1984) argues that modern ICTs not only automate activities and work processes but they also translate them into information. Modern ICTs work on and change their objects; at the same time, they also generate information about the underlying production and administration processes. This means that while contributing to the development of a product, modern ICTs also reflect back on their activities and on the system of activities to which they are related.

The new information created by modern ICTs can be used in different ways. It can function as a device to *monitor and control production and work processes*. By imposing information in the form of programmed instructions, management can increase its control over work processes and immediately intervene when needed. The informating function of modern ICTs, however, can also be associated with processes of innovation and learning, as ICTs produce new information directly at the workplace. When immediately used by workers such information can lead to processes of continuous improvement. As modern ICTs contribute to direct feedback between the generation and the application of new knowledge, they add a *new dimension of reflexivity* (Castells 2000). Through continuous monitoring of their work, made possible by ICTs, workers learn and they are able to convert the knowledge into new products and services as well as process innovations. Of course, making use of the new dimension of reflexivity also implies a new way of computing that *moves intelligence out into the enterprise* (Tapscott 1995, 100).

The communication function

The real revolutionary development, however, is that, due to the development of telecommunications integrating the computer with communication technology, modern ICTs develop into communication systems, which leads to a new type of

business architecture and to structural changes in inter-company relationships. ICT can be conceived of as a medium connecting people with each other as well as with machines. Increasingly, ICT is becoming an *important device to facilitate and support information flows* within and among companies, as more and more communication is technically mediated. ICT changes from an inwardly oriented technology that forms islands of information and automation to an *outwardly oriented technology* that supports the formation of inter-organisational networks electronically.

The use of intra- and extranets especially for supply and demand chain integration (electronic commerce) and for internal operations of the company or other LAN-, WAN-, and VPN (virtual private networks) -based collaborative technologies and applications, make it possible to materially implement the networking logic in all kinds of processes. "The morphology of the network," as Castells argues, "seems to be well adapted to increasing complexity of interaction and to unpredictable patterns of development arising from the creative power of such interaction" (1997, 61). It is not just that computers are linked to each other and exchange information, but the trend is towards *'cooperative computing'*, regardless of the location of the interactive partner (Castells 2000). We can speak of the development of a *technical platform* for using ICTs as a collective tool (Baukrowitz 1996).

One of the major impacts of modern ICT as network technology and communication medium is the further acceleration of the innovation process. While modern ICTs do not automate innovation activities, they become an *enabling technology.* R&D and manufacturing bases dispersed globally may be connected with each other as well as with central corporate files through the database network system. In this system, researchers may interact with each other globally for discussion and consultation through electronic mail. Designers may retrieve information from the central file about the availability of parts with derived specification for product development. Any engineering change occurring at a certain factory is fed back and incorporated into the original design stored in the central file and made available to any factory using the same global design (Aoki 1989, 18).

It is important to mention that modern ICT supports *both natural language communication and formal communication*, or to put it differently, it supports the exchange of codified and tacit knowledge. The fact that modern ICTs open up access to information bases and electronic networks is important for companies' innovation processes. Because of codification of information and knowledge associated with the use of modern ICTs, data and information are much more accessible than before to all actors that are linked to information networks or know how to access such networks (Soete and ter Well 1999, 9). The use of network technologies makes it possible to keep up with constantly renewed information in a globalising economy. Being technically connected with key knowledge producers gives companies the opportunity to continuously monitor and be informed about technological change. Actually, modern ICT is becoming the first global technology, the more the potential for international codification and transferability increases.

The fact that information and knowledge are globally available does not mean, however, that access to and the effective use of information and knowledge is equally spread worldwide. On the contrary, this depends on the competence available to access international data bases and information networks. While codification is a precondition for modern ICTs to function as global information technology, *tacit knowledge* is needed to make effective use of the global access potential (ibid.). When it is no longer important to have all the 'know-how' necessary to develop a new product at one place, then such tacit knowledge of knowing what 'know-how' is needed, where it is available and how it can be combined becomes increasingly important.

Universal availability of all knowledge stored in digital form is one aspect of modern ICT that supports companies' innovation activities; the other is the *universal reach of knowledgeable persons.* Concerning the second aspect, modern ICTs are used to deal with communication that is not formalised. Here the focus is not on the capability of modern ICTs to substitute for tacit knowledge; from this perspective, the emphasis is on their *potential to reinforce human interaction and interactive learning*, as Ernst and Lundvall (1997) argue, and on how they can *support and mobilise tacit knowledge*. We can conclude that in order to support innovation, technical connectivity needs to include both the exchange of codified and of tacit knowledge. There are, however, limits to modern ICTs to function as communication-enabling technology. The exchange of *distance-sensitive knowledge* still needs face-to-face contacts.

Modern ICTs, as has been discussed above, can contribute significantly to companies' innovation activities. However, it is not the technology itself that is important in this respect but the way in which companies make use of it. While modern ICTs can hardly automate innovation processes, they can become *enabling technologies.* In particular, used as information and communication technology, ICTs can support and accelerate innovation processes. As information technology, they add a reflexive dimension, allowing employees to continuously learn on the job and introduce incremental innovations. As communication technologies they improve knowledge exchange that is important for interactive learning and collaborative development of new products or processes.

New organisation forms

ICT and organisational restructuring

Modern ICTs themselves have only a limited impact on innovation and economic growth; major progress can be realised when ICT investment is combined with other organisational assets, such as new strategies, new business processes, new

organisation forms, and better worker skills. Modern ICTs differ from some other 'general-purpose technologies' insofar as their successful integration requires *significant structural adjustment* (OECD 2000b, 55). Actually, organisation forms are given increasing priority among researchers by stating that modern ICT has to be implemented in the existing organisational framework and formed according to organisation needs (Brousseau & Rallet 1998, 245). ICTs are not external factors, but they develop in organisations. They penetrate all work processes, "not as an exogenous source of impact, but as the fabric in which such activities are woven" (Castells 1997, 31).

Modern ICTs and organisation forms are truly homologous forms; ICTs create new organisation forms and new organisation forms, in turn, provide new opportunities for technology design. Neither technology nor organisation is fixed, but both are changing in relation to each other (Lucas and Barondi 1994, 9). ICTs offer opportunities to manipulate both the communication technologies themselves as well as the organisation contexts in which they are embedded according to specific aims. They provide, as Fulk and deSantis argue, more than traditional technologies, 'occasions' for structuring the production process according to *other drivers of change* (1995, 337). In the emerging knowledge economy, global innovation competition, as we have argued above, is becoming the dominant driving force. To be able to stay competitive in the global markets, companies have to adapt techno-organisational structures to the needs of this new driving force.[55]

Changing restructuring practices

Together with the introduction of modern ICT, *new patterns of organisational restructuring become visible*[56]. The single workplace or isolated work processes, on which traditional restructuring strategies focused, are no longer the main target of current transformation processes. It is obvious that concentrating on *piecemeal change strategies* will not enhance companies' innovation capability significantly and will not, therefore, guarantee companies' survival in a global economy. Actually, these piecemeal strategies often reduce the knowledge base of firms instead of broadening it, as they focus on the short-term aim of cost reduction.

To fulfill changing expectations in global markets, companies have to apply a new restructuring approach. This implies that *systemic restructuring strategies* are applied (Altmann et al. 1986) taking the whole business organisation as the starting point for restructuring (Tapscott 1995, 28). Global innovation competition

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[55] Of course, traditional goals of increase productivity and reducing costs also remain strategic goals in global markets. There is no doubt that techno-organisational structures will vary, depending on whether companies producing standardised mass products aim at cutting costs or whether they produce complex, knowledge-based products aiming at continuous improvement of their products.

[56] See also the concept of high-performance workplaces (OECD 1998a).

demands more than just lower-level process modelling; actually, the whole business model is at stake. This is frequently expressed in terms of the *'holistic view'.*

Another aspect of the new restructuring strategy is a focus on *process instead of structure*. It is no longer possible to simply take an already existing organisation model out of a toolbox and implement it through a top-down process. Instead, restructuring implies a *continuous process of organisational renewal and learning*, which involve a great number of organisation members. We can, as the Green Paper 'Partnership for a New Organisation of Work' states, identify a shift from fixed systems of production to a *flexible, open-ended process of organisational development* (European Commission 1998). The transformation process often has the character of an *experimental process*, which has no clear outlines and does not appear as an integral whole.

The servicisation of production processes

Companies cannot reap the benefits of the new knowledge available to them without undertaking major internal restructuring processes. On the one hand, intra-organisational change includes the emergence of *new activities and processes*; on the other hand, it contains *new configurations of social relationships* (Murray and Wilmott 1995, 168).

When we discuss organisational restructuring, the increasing *servicisation of production and the growth and raising proportion of knowledge-intensive functions* is particularly noteworthy. In this respect, we first have to mention that due to the fact that value-added is mainly generated by product and process innovations, the *design function* is becoming crucially important. "Quicker innovation", as Lash argues, "entails that a lot more work must proportionally go into the designing of new products. It entails that a far greater proportion of the production process than heretofore must be accounted for by a knowledge-intensive 'design process', and a smaller proportion by the 'material process'" (Lash 1994).

But innovation also depends upon the *research potential of the company*. Although the results of basic research conducted in universities and state research institutes are publicly available, it takes constant investment effort in research for companies to be able to interpret and use abstract scientific knowledge. Companies can rarely make use of the new theoretical knowledge if they do not conduct research themselves; they must have *absorptive and transformative capacities*.

As *customisation* becomes increasingly important, more work will also go into *marketing*. First, it is important to know more about customers' needs to be able to provide products or services that can be sold. Furthermore, customers no longer accept standardised solutions for their problems; instead, they expect *specialised solutions* for problems they are sometimes not even able to clearly define. It, therefore, becomes necessary for companies to develop new products or services in close cooperation with their customers. In addition, an increasing number of

customers do not only buy products or services; they demand complex solutions, which often include *long-term after-sales services.*

The globalisation process also places high demands on the *management function.* Planning is becoming more difficult under the conditions of increasing uncertainty. The same holds true for the *organisation function*, since the design of production and service processes is becoming a process of learning and continuous improvement. We can conclude that more work will not only go into indirect work, but also into management work. We also have to mention the increasing demand for *further training*. Continuous incremental improvement as well as permanent organisational adaptation and renewal can only be realised if workers get the chance to improve their knowledge continuously through lifelong learning.

The transformation of work seems to indicate that more and more employees will be working in knowledge-intensive service and management functions and fewer in core production processes. Then the *'knowledge worker'* becomes the key person in production (Tapscott 1995; Reich 1992). This group of workers includes "those which manage and operate across global networks, those which are capable of offering design intensity, those which can provide high added value to products and services through scientific excellence, imaginative skill, financial acumen, or even effective advertising" (Robins and Webster 1996, 9).

Companies, however, often seem to follow a strategy of strengthening the role of *direct work* empowering workers on the shop floor. This takes place through integrating both indirect work as well as management functions into core business activities, while those parts of the direct work with codifiable knowledge become increasingly automated. This development is in line with the argument of Nonaka and Takeuchi (1995) claiming that all workers should be considered as knowledge workers. Beyond knowledge engineers and specialists, there are knowledge practitioners, who reflect on and share accumulated tacit knowledge. The importance of complex jobs at the operational level, facilitating innovation and organisational learning have also been stressed by other scholars (Steedman, Mason and Wagner 1991). However, whether there is a general trend towards strengthening the role of direct work while reducing both the share of functional specialists performing indirect work and the share of people in middle management still remains an open question.

The changing configuration of work relationships

One aspect of modern ICT, as mentioned above, is that they enable direct communication among organisation members. Therefore, they *undermine the traditional Fordist production model* based on the following two main principles: vertical integration and hierarchical control, on the one hand, and functional specialisation and horizontal de-integration on the other. Actually, this traditional model includes in-built mechanisms to block information and knowledge flows; due to its bureaucratic structure and far-reaching division of labour, the model

produces too many interfaces both hierarchically and vertically, which become a hindrance to communication and information exchange. There is a risk that within the Fordist production model too much information gets lost, particularly as in the bureaucratic control system, the broad middle management is mainly dealing with the routine filtering of information.

Growing innovation competition forces companies to orient restructuring processes on the *market logic instead of the production logic*. Companies organise their production process around customer-oriented processes rather than business functions. Such restructuring is made possible by modern ICTs, as they facilitate the sharing and co-ordinating of information among different organisation members and units. The principle of organising companies on the basis of integrated, ICT supported production processes dissolves boundaries between functionally specialised units as well as between hierarchical levels, and therefore, facilitates information and knowledge exchange.

This reduces the need of middle-level managers and allows the *flattening of hierarchies* (Murray and Willmott 1995, 168) and the introduction of *semi-independent work groups* linked laterally rather than vertically (Lipsey 1999). Work groups become responsible for self-contained production processes without a fixed division of work among their members. Work groups have to organise themselves and they are expected to continuously optimise the way in which they organise their work. But at the same time, by monitoring each other, work groups are also expected to continuously improve cooperation and information exchange. 'Learning by doing' and 'learning by interacting' are important aspects of group work.

Modern ICTs allow direct communication with the external environment on the shop floor. Direct contacts of work groups with customers, suppliers, and consultants implies that many unproductive activities, such as control and waiting for decisions taken higher up the ladder, are made redundant. Modern ICTs can technically support decentralised direct cooperation of work groups within different organisations and intensify and accelerate information and knowledge exchange.

The development of semi-autonomous work groups reduces the need for these units to be a formal part of the firm and allows firms to *outsource activities* and concentrate on their core competencies. Large companies reduce their size and become leaner to get the same entrepreneurial dynamism, innovativeness, and informalism as small companies have. All functions and processes that do not belong to the core of the business can be subcontracted to other companies specialising in these activities.

Outsourcing results in smaller organisations with a simpler structure; these are supplied more frequently with products in smaller batches and therefore become more dependent on other companies. In the extreme, progressive outsourcing can lead to a form of firm organisation in which constellations of various firms combine to work on a particular project and then disband. Furthermore, companies may subcontract all production and become concerned only with knowledge-intensive functions, such as product design, marketing, and the management of

all activities in the chain conducted by other companies. Electronic networks make such specialisation processes possible, since they reduce the costs of coordination and transaction. Companies have realised, however, that due to intensive outsourcing they risk to loose important assets. We can, for example, see a reverse of the former trend of outsourcing knowledge-intensive services, as companies start viewing them more and more as part of their core business processes and competencies (Leiponen 2001).

Nowadays, the strategy of process integration is also discussed as a solution for the exploration/exploitation dilemma. The establishment of *'trans-functional design teams'* creates a new style of innovation management reintegrating research and development with engineering, design, procurement, production, and marketing even in the largest companies (Freeman 1987, 44). The concept stresses the *importance of cognitive diversity*, as it tries to integrate the competencies of various expert groups right from the beginning.

The development of new products, market assessment, price calculation, and the organisation of new work processes — all these activities are performed within a cross-functional team consisting of members from various departments and sometimes even members from supplier firms and customer organisations. All products are designed with manufacturing in mind, which reduces expensive processes of redesign and also speeds up the marketing of new products. Firms can 'tool up' long before the actual manufacturing stage has been reached.

Trust-based business culture

Modern ICT applications and new organisation forms seldom produce the expected results with respect to the stimulation of communication and knowledge exchange. Modern technological infrastructure supported by flexible organisational rules allows anyone to post information and gives access to all available information, insofar as it is a necessary prerequisite for extensive information and knowledge exchange. But modern ICT is only the pipeline and storage system for the exchange of information and knowledge; it does not affect this exchange.

Firms have to direct and align perception, understanding, and evaluation by the people connected with it in order to achieve anything at all (Nooteboom 1999a). The literature points to the importance of *fundamental cultural changes* to enable and facilitate knowledge sharing (Murry and Willmott 1995). In a corporate culture that does not favour information and knowledge exchange, knowledge sharing will not take place, even if the firm has the most modern ICT applied (Davenport and Prusak 2000, 18). Techno-organisational structures alone cannot create an environment fostering continuous exchange of information and knowledge, they must be based on a supportive business culture.

When companies establish new organisation forms, supported by the use of modern ICT to stimulate and accelerate information and knowledge flows, they can no longer rely on a weak, distrust-based corporate culture. Instead, a strong, trust-based culture is needed for decentralised and highly flexible firms to function effectively. A trust-based firm culture creates an environment in which the promise of reciprocity is high and in which employees feel obliged to share their information and knowledge with other organisation members. When we talk about strong trust relationships, we mean *identification-based trust,* resulting in moral involvement, which can be distinguished from calculus-based trust (Lewicki & Bunker 1996).

Companies see *programmes of cultural strength* as an important part of their renewal strategies. "Such programmes", as Murray and Wilmott argue, "draw together and energise often fragmented and conflicting organisational forces around core values that would guide the work of all organisation members from Chief Executive to clerical staff" (1995, 171). Cultural change programmes reflect a rethinking of how to tap the creativity and adaptability of the human being and link the management of employee skills, competencies, and careers more directly to the pursuit of business strategies. There seems to be some evidence showing that human resource management in concert with a more strategic approach contributes to the sustainable competitiveness of companies. The *creation of a company vision* can be seen as an attempt by management to support the development of a strong corporate culture.

The rise and increasing spreading of *total quality management* is another very visible sign of increasing attention being given to a more holistic approach to management, including the establishment of a strong organisation culture. Total quality management views the enterprise as a totality of interrelated processes and activities, aiming at continuous incremental improvement. "Its emphasis is on managing internal as well as external customer relations where various measures of quality can be improved inter alia by eliminating bottlenecks and costs associated with a failure to 'get it right first time'" (Murray and Willmott 1995, 171).

It is, however, highly disputed whether companies can establish a strong trust-based organisation culture by setting up programmes of cultural strength. Some companies, therefore, focus more on *creating opportunities for employees to meet informally* and to talk and listen to each other. They have established spaces to make informal information and knowledge exchange more robust among employees. This practice is based on the assumption that these meeting points can create an atmosphere in which trust can develop, and this can stimulate the exchange of even tacit and ambiguous knowledge. At the same time, this allows the development of a *more diversified and fluid organisation culture*, which supports the flexibility of network organisations.

Physical spaces can be supported by *virtual spaces*, but should not be replaced by them. The Internet, Intranet discussion groups, and groupware discussion databases have the advantage of convenience and choice because they allow access to a vast variety of different knowledge sources. But their downside is that

they do not allow for personal contacts, which as Davenport and Prusak argue, reduces trust and commitment (2000, 47). Physical places, on the other hand, reduce access to available information, since they allow only a limited number of contacts. Therefore, a combination of physical and virtual places may provide the best solution for stimulating information and knowledge exchange in order to accelerate innovation processes.

Modern ICTs, we have argued above, will only support and accelerate innovation activities when accompanied by organisational restructuring processes. It is, however, obvious that traditional restructuring strategies, focusing on single work places and isolated work processes cannot enhance companies' innovation capability to a great extent. Instead a restructuring strategy is needed that aims at transforming the whole business model, including the introduction of knowledge-intensive service functions, the flexibilisation of internal organisation forms and the development of a trust-based business culture. But new techno-organisational structures also create demand for new skills and competencies.

Human resources

A general trend towards up-skilling?

Although modern ICT allows increasing codification of knowledge, large amounts of knowledge remains tacit – embodied in peoples' skills, competencies, and experience. Human capital is, therefore, crucial to companies' capacity to produce new products and apply new process technologies as well as to work in restructured work environments. The lack of skilled personal is often seen as a factor seriously limiting innovation and economic success (Stahl et al. 1993, 26). The term *'skill-biased technical change'* indicates that there is an increasing need for new skills and competencies in the emerging knowledge economy. The effect of modern ICT on labour demand involves, however, far more than simple automation and substitution; instead, new skill demands are related primarily to the *central role of ICT-enabled organisation change* (Bresnahan et al. 1999).

It is often argued that the widespread use of modern ICTs, accompanied by new innovative organisation forms, implies a general trend towards *up-skilling*. This assumption is based on the following aspects:

- continuing increase of the number of researchers and scientists in the labour force;
- the need for new ICT experts;
- the replacement of jobs in production with jobs in knowledge-based services, such as design or marketing; and
- a trend towards reintegrating service and management functions into shop-floor jobs.

Although rather heterogeneous, these trends nevertheless support the argument that the role of human capital in the emerging knowledge economy is increasing. One can question, however, whether the traditional controversy over a de-skilling or re-skilling impact of modern ICTs tackles the skill problem in the right way. Here we discuss some specific aspects of human capital. First of all, there is no generally accepted definition of human capital. In the OECD Report on 'Human Capital Investment', the following meaning of human capital is adopted: it comprises "the knowledge, skills, competencies, and other attributes embodied in individuals which are relevant to economic activities" (1998b, 9).[57] This definition indicates that human capital is a *multidimensional concept*. Instead of talking about other attributes, we will speak more concretely about work orientations, work attitudes and work values.

New skills and competencies[58]

Breshnahan et al. (1999) associate current techno-organisational restructuring with increased demand for *cognitive skills*. The concept is concerned with mental processes of a higher order: knowledge is built up and applied to problem solving. One aspect of cognitive skills is that due to the capability of modern ICT to collect and store huge amounts of data, *human interpretation and judgement in decision-making* becomes crucially important. Also, the introduction of computer-based decentralised organisation forms calls for cognitive capabilities, as people on the shop floor who are directly involved in digital information flows have to have processing capacity to handle information. And they must be able to combine information or experiences of various kinds, a competence characterised as *combinatory skills*. The expectation that workers continuously improve their products and work processes also puts increasing demands on their cognitive capabilities.

Due to the transformation of work into *problem-solving processes*, workers are increasingly confronted with new and unfamiliar tasks as well as complex and ill-defined situations for which no solutions are yet available. In such situations,

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[57] For an intensive discussion of the various concepts, see Raivola et al. (2001) and Hakkarainen et al. (2001).

[58] We are aware of the fact that such an undertaking is confronted with a specific problem. The concepts of skills, competencies, and knowledge are far from being clearly defined, no generally accepted definitions exist, and it is also very difficult to separate the various concepts from each other. There is the risk that one comes up with an infinite number of skills and competencies needed in the emerging knowledge economy. We have tried to avoid this problem by identifying the main challenges of techno-organisational restructuring currently taking place within companies needed to prepare for the emerging knowledge economy.

workers can draw only to a limited extent on their content knowledge; instead, they need to have at their disposal *theoretical knowledge*. To find solutions to new problems, workers must have the ability to ask the right questions, to find the information needed, and to select the most suitable aids and tools. They must be able to conceptualise new problems in such a way that they can search for solutions by proceeding in the appropriate systemic and methodological way (European Commission CCAM Contract #76246). In manufacturing processes, methodological knowledge and knowledge about process engineering becomes more important than the skilful use of tools and material. The skill profile of workers becomes more professional and loses its craft basis (Kern and Sabel 1994, 611).

While complex problems cannot be solved without advanced conceptual tools and models, employees can make effective use of them only if these have been applied and developed in the course of problem-solving processes. Employees must be able to understand how to use theoretical knowledge in practice; this means that *theoretical and practical knowledge need to be integrated* (Hakkarainen et al. 2001). Manufacturing, for example, no longer consists of direct interference in the production process; instead, the principal responsibilities of workers include monitoring, controlling, and regulating technical processes and systems. The use of modern technology leads to uncertainties and problems that are difficult to plan or predict. In concrete situations, these uncertainties cannot be solved on the basis of the strength of theoretical knowledge and a systematic way of thinking alone; practical knowledge is also needed which enables people to react immediately to new and uncertain situations.

We can further identify the need for *multiple or interlocking skills* as a major trend. New organisation forms are characterised by the erosion of the traditional division of labour; they are based on principles such as re-integration of divided jobs and de-specialisation. If one wishes to participate in the dynamic process of developing group work, it is not enough to have skills in only one specific profession. The extensive group process integrates various core functions with indirect functions, such as quality control, repair work or programmeming, to mention a few, and also with some disposition functions. When work is primarily structured around a small number of business processes linking the activities of the employees with the needs and capabilities of the customers, the canon of professional skills the workers must have expands.

Hakkarainen et al. argue that *multi-contextual expertise* would render possible better horizontal cognitive mobility. "Horizontal mobility means that the expert is able to cross the borders of traditional fields of expertise. Partly this means skills of achieving increasing mutual understanding in interaction with specialists representing other fields. In many complex problem-solving situations horizontal mobility also implies an individual's ability to move between different perspectives and to integrate the expert knowledge of those traditions" (2001, 196). Sometimes, the authors continue to argue, multi-skilling and horizontal mobility are an insufficient basis for finding new solutions in complex and surprising problem

situations. Instead, *vertical mobility* is needed, which implies that an expert is capable of decontextualising a problem and to derive new hypotheses by co-ordinating theoretical prior knowledge at a very abstract level. Here the authors refer to the need to combine theoretical and practical knowledge related to specific fields.

The advancement of modern ICTs is fundamentally influencing the demand for new skills. As stressed earlier, modern ICTs make the exchange of information and knowledge among various actors much easier, as they bridge both time and space. It is expected that due to the easy access to technological databases, vastly expanded connectivity, and a sharp rise in communication bandwidth, modern ICTs will significantly speed up innovation processes within firms. Those advantages, however, can only be realised if employees are capable of using modern ICTs in an efficient and creative way. This includes both the competence to access electronic networks and the competence to sort out relevant information. Together with the widespread use of modern ICTs, technical skills and competencies — one can also speak of digital skills — are becoming crucially important.

But to make efficient use of the great potential of modern ICTs, it is not enough that employees can handle new technologies and sort out relevant information, they also need to possess more general collaboration, information processing, and communication skills. *Digital skills*, we can conclude, need to be combined with *social skills* (Hakkarainen et al. 2001). The term 'social skills', however, comprises a large number of more specific skills and competencies; there is no clear definition of this type of skills. Social skills include the following elements: flexibility in attitudes towards new tasks, autonomy in decision-making and willingness to shoulder responsibility, self-confidence in defending one´s own ideas within the working group, ability to express one´s own views and thoughts, tolerance for the argumentation of others, willingness to cooperate and to support the others if necessary, and willingness to jointly search for a compromise in conflict situations. It is important that employees not only acquire these skills but also learn to understand the value of social collaboration (Hakkarainen et al. 2001, 186).

Here we outline some arguments as to why social skills are becoming increasingly important. Given the mutual dependence of workers within work processes, they will be increasingly required to cooperate and communicate with each other. Due to the trend towards decentralisation, workers also have to keep direct contact with members of other work groups. Social competence, therefore, is often related to the ability to take part in teamwork processes in such a way that the outcome of the group work will be seen as a collective achievement. Another reason why social competence or skills will become important is that, together with higher levels of autonomy and decentralisation of decision-making, workers will more often be speaking directly to suppliers and customers.

The process of organising a business globally will call for a range of new skills, which can be classified as *international skills* (Dertouzos et al. 1989). They are not reduced only to the ability to speak foreign languages. Furthermore, today this

does not only involve large companies: even in the case of medium-sized and sometimes of even small 'high-tech' firms, dealing with foreign clients or suppliers is just normal business, as the globalisation of markets and international integration accelerate. In these international relationships, cooperation is much easier if one knows about the culture, tastes, customs, legal systems, and institutions of the business partner's country.

Due to the flattening of hierarchies and increasing project work, decision-making is more and more decentralised and more responsibility is handed down to the operational level. Work groups must be able to plan, organise, and control their work autonomously. They have to establish, sustain, and renegotiate exchange relationships with cooperation partners both within the firm and from the outside. Furthermore, workers are becoming responsible for the quality of their work, for achieving the agreed cost limits and for delivering their products at the agreed time. Group autonomy can also include the right to select new members. All these are tasks earlier performed by management — planning, organising, negotiating, control and decision-making — are seen as typical management functions. This means that the new forms of organisation can only function if the workers acquire the necessary *managerial or executive competencies*. The *capability to manage information flows and dynamic networks* are particularly important (Hakkarainen et al. 2001).

The more such aspects as quality and time gain importance as criteria in global competition, the more the success of a company depends on specific *work orientations and virtues,* such as quality consciousness, precision, and reliability. However, more than these work virtues, *creativity, determination, and entrepreneurial spirit* are becoming crucially important qualifications.[59] The transformation of such abstract concepts as continuous product and process improvement into reality depends a great deal on a creative workforce. Being creative means inferring a course of action from a synthesis of diverse pieces of information (Frenkel et al. 1993). *Entrepreneurship* can be characterised as willingness to try new things and to take the risk of failure as long as high gains may be anticipated. It implies that employees engage in exploration activities in organisational practices (March 1991).

The following table gives an overview of the key dimensions of techno-organisational restructuring and related new skills, competencies and knowledge.

Dynamic development of expertise[60]

Employees are increasingly confronted with the demand to deal with problems in unknown situations. They need to have the background to cope with increasing uncertainty and new problems, a situation, which cannot be managed on the basis of their current capabilities. Confronting and solving new problems means that

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[59] Innovativeness and creativity are sometimes viewed as very different skills.

[60] For an extensive discussion, see Hakkarainen et al. (2001)

Qualifications	Restructuring aspect
Knowledge	
theoretical knowledge	solving new problems
technical (digital) knowledge	introduction of modern ICTs
practical knowledge	immediate reaction to unexpected events and problems
Skills	
cognitive skills	selecting, analysing, judging and interpreting an increasing amount of data
professional skills (multi-skilling)	integration of tasks, de-specialisation, group work
international skills	globalisation of markets and production
social skills	direct interaction within and between work groups, direct interaction with customers
management skills (information management)	flat hierarchies, decentralisation, increased information exchange
Work orientations and work virtues	
quality consciousness, reliability	quality and time as key aspects of global competition
creativity, entrepreneurship	innovativeness as key element of global competition, re-inventing new technologies
leadership (management)	coordination of autonomous work groups
new work virtues	commitment, trust

Table 7. Techno-organisational restructuring and new qualification needs.

employees must be able to *transcend these capabilities* and to continuously acquire new skills and competencies; they have to dynamically develop their expertise. 'Progressive problem-solving' is the basic mechanism of dynamic development of expertise (Bereiter and Scardamalia 1993), and the kind of expertise relying on progressive problem-solving can be called 'dynamic expertise'. We may also speak about *'learning to learn competence'* (European Commission CCAM Contract #76246), as the capability to continuously learn new thing enables an individual to transcend its current expertise and to solve unknown problems.

What is important in developing dynamic expertise is the possibility and preparedness *to work on the edge of one's competence and to take up more challenging problems*. This means that dynamic expertise results from the interaction between personal attitudes and the character of work. In addition, organisational aspects are important, as they can either support or hinder the development of dynamic expertise or 'learning-to-learn' capability. Dynamic work groups and corresponding decentralised organisation forms facilitate the development of dynamic expertise, as individuals are continuously faced with new problems in those structures. Also, the organisational environment plays an important part in the dynamic process of developing one's expertise. Environments characterised as 'turbulent fields' create more problems and challenges than a placid and simple environment. This means that companies in high-tech industries with rapidly changing requirements are more likely to foster employees to develop learning-to-learn capabilities.

Dynamic development of expertise is not only an individual accomplishment but also depends on adopting relevant cultural knowledge and practices through collaborative activities. To be able to develop dynamic expertise, employees *have to have access to relevant expert cultures* that carry culturally and historically accumulated knowledge (Hakkarainen et al. 2001, 63). Peripheral participation, also called *cognitive apprenticeship*, is a process during which people gradually adopt experts' silent knowledge, culture, and activity, and grow up to be members of that expert culture. It is, therefore, important that companies create organisational structures that allow employees peripheral participation in various working groups in order to develop dynamic expertise.

Conclusion

In the emerging new economy, innovation becomes the key competition factor. As firms are the main carriers of technical innovations, their capability to innovate is decisive. For companies to accelerate and increase their innovation activities, the introduction and intelligent use of modern ICTs as information-producing and communication-enabling technologies become crucially important. However, major progress appears to be realised only when ICT investment is combined with other organisational assets, such as new strategies, new organisation forms, a trust-based business culture, and better worker skills. Traditional piecemeal change strategies, however, will not produce the productivity increases and innovation dynamics needed to survive in the emerging knowledge economy. Instead, systemic restructuring strategies have to be applied taking the whole business organisation as the starting point for restructuring.

It has been argued that the fundamental restructuring processes within companies aiming at increasing innovation capability need to be supported by up-

skilling processes in white-collar jobs in particular. We do not want to question this argument; however, there is a need to designate more concrete the new skills and competencies demanded in a business environment of innovation competition. One can name a range of new skills and competencies, among them digital skills, cognitive skills, social skills, management competencies, and international skills, which become important when companies are facing increasing global competition, but the 'learning-to-learn capability' must be stressed in particular. The following figure gives an overview of the various dimensions of holistic business restructuring processes.

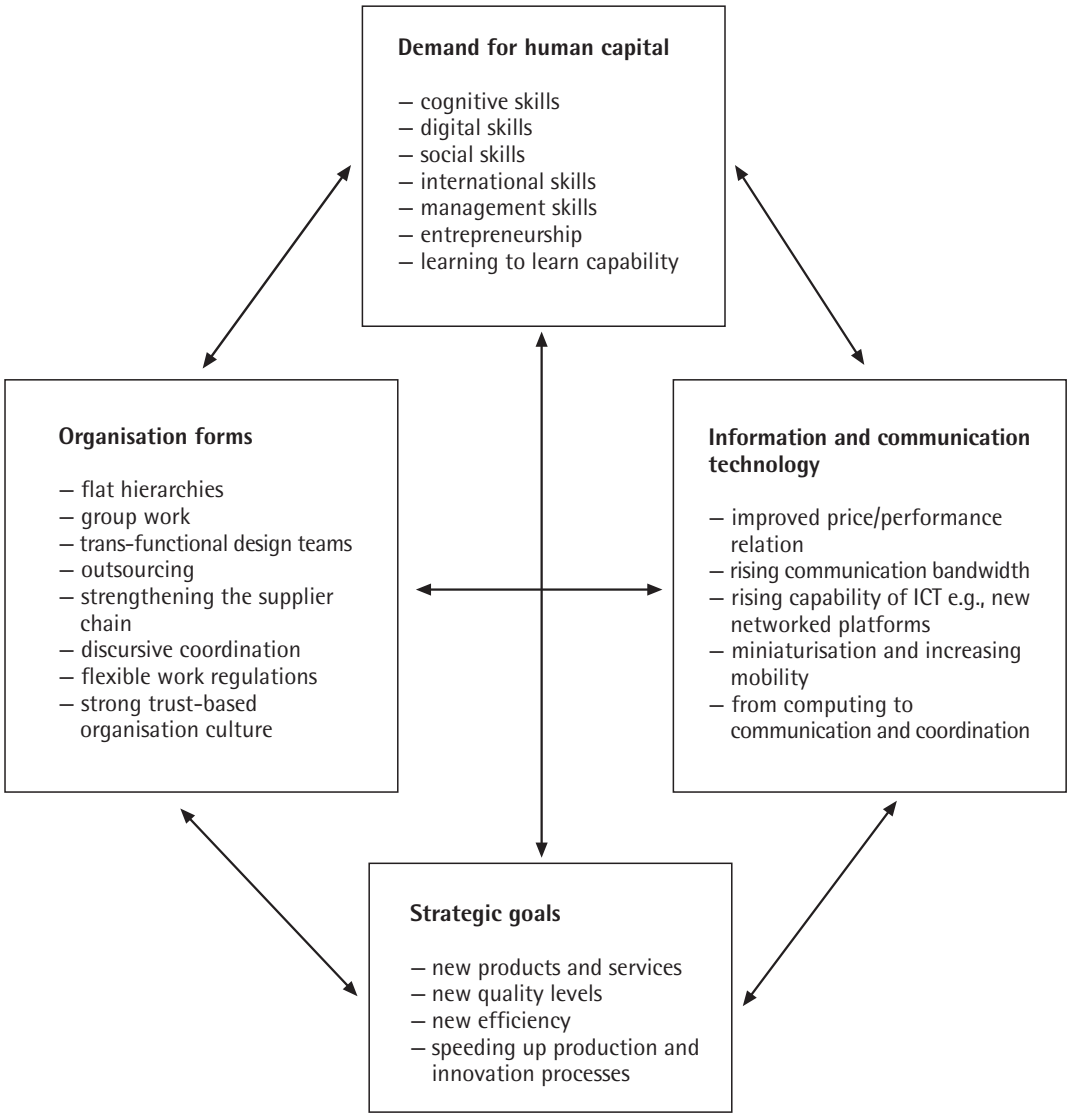

Figure 6. Dimensions of holistic business restructuring.

8 INTER-FIRM NETWORKING

Together with the application of modern ICTs companies increasingly change from an *inward to an outward orientation of restructuring* (OECD 2000b). A new phenomenon linked to the outward orientation of companies is the *increasing inter-firm cooperation.* According to Hage and Alter (1997), we can distinguish between older, more traditional cooperation forms among producers and suppliers and new types as, for example joint ventures, strategic alliances and inter-organisational networks[61]. Innovation increasingly derives from a network of companies interacting in a variety of manners. These new forms differ from the traditional ones in various aspects.

While traditionally cooperation between companies was reduced to more simple tasks, as for example co-ordinating prices, pooling financial resources, or marketing, it now involves more complex ones, including joint research and production of products or services (Alter and Hage 1993; Gomes-Casseres 1994). By building more broader and deeper inter-firm networks than before, companies try to *promote their strength and to eliminate weaknesses* (Powell 1990). Furthermore, the span of strategic alliances has broadened, crossing industrial sectors rather than being contained within them. In addition, the same firm is now involved in a number of different types of networks as R&D networks, marketing networks, and production networks, for example, which puts greater demands on companies' capability to manage the web of often overlapping networks (Gomes-Casseres 1994). Of course, depending on the industry they belong to, companies will focus on different functions when becoming engaged in inter-firm networks. In low-tech industries,

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[61] In the following, we will only use the term network, but we are aware of the fact that the term covers different types of inter-firm cooperation.

production and marketing networks are likely to dominate, whereas in high-tech industries companies will primarily engage in R&D networks. Also the membership of strategic networks has become more diverse; these frequently involve a third party to ensure the enforcement of agreements (Hage and Alter 1997).

Strategic networks are not based on the assumption of a zero-sum game; instead the underlying idea is that the partners can gain from sharing knowledge by *jointly optimising benefits and reducing risks*. Together with the rise of strategic alliances we may see the *reappearance of technological innovation objectives*. While in a world of increasing competition financial investments gain the upper hand over production investment cooperation in strategic networks can coincide with a refocusing on production, knowledge flows and a broadening of the knowledge base leading to major innovations (Michalet 1989, 17). But when exactly are cooperative networks the most efficient and innovative organisational alternative? When do network relationships have a comparative advantage over the market mechanisms or the private and public hierarchies? After all, markets, hierarchies, and networks all co-exist in modern economies. Only their relative importance in particular contexts has changed.

Despite the growing volume of research on networks, their comparative organisational advantage in modern economies has not been adequately explained in the literature. Most theorising takes a partial approach and neglects many important dimensions of organisational efficiency and innovativeness. For example, the transaction cost literature does not include production and coordination costs as key determinants of economic efficiency, nor has it anything to say about the value-adding or innovation consequences of alternative organisational arrangements (Hämäläinen 1993). This chapter will provide a more holistic framework of economic organisation that takes these organisational determinants more seriously. In particular, we will attempt to explain how the current paradigm shift in the world economy has increased the comparative advantage of networks in economic organisation. Network cooperation has become an increasingly efficient and innovative way of organising interdependent activities in modern economies.

Different types of networks

The concept of "network" has become so popular during the past ten years that critiques are already talking about its abuse (Grandori and Soda 1995). However, despite widespread use, there is little consensus about the appropriate definition of networks. As we will see below, this reflects the numerous forms that networks can take.

Networks are often characterised with the concept of "loose coupling": various independent actors develop relatively loose relationships among each other to pursue some common goals (Johannison 1987, 9). Network relationships and

cooperation usually take a relatively long period of time to develop. Once established, cooperative networks tend to be characterised by high degree of specialisation and interdependence, intensive communication, reciprocity and high levels of trust (Hämäläinen 1993; Nahapiet and Ghoshal 1998). However, occasional conflicts and power-asymmetry may also characterise networks. The focus of network analysis is more on the relationships and interactions between interdependent actors and organisations than on these actors or organisations themselves.

Networks have been analysed by researchers from many different disciplines with varied research interests and approaches. They have focused on different aspects and levels of network formation. Some researchers take an interpersonal perspective and emphasise the non-economic bases of social exchange and the importance of interpersonal relationships for productive cooperation, economic efficiency and innovativeness (Granovetter 1973; Miettinen, Lehenkari, Hasu and Hyvönen 1999). Others emphasise the structural approach and focus on the configuration, number and quality of network ties (Nahapiet and Ghoshal 1998; Mattila and Uusikylä 1999). Still others focus on the institutional nature of networks and define them as a distinct organisational alternative relative to markets and corporate hierarchies (Powell 1990; Williamson 1991).

There are many different types of networks in modern economies. They can be divided into *vertical* and *horizontal* networks according to the value-adding chain (Porter 1985; Kuusi 1999). Vertical networks connect firms, value-adding activities or individuals along a particular value-adding chain; whereas horizontal networks connect them in particular functional areas (such as research, production, logistics, marketing, etc.). In recent years, network-type of arrangements have also been created between public and private sector organisations. For example, such *public-private partnerships* have been used to improve the efficiency of public service provision (Le Grand and Bartlett 1993) and to combine certain public goods with private sector resources in commercial activities (Nelson 2000; Lennon 2001). The commercial utilisation of the basic research conducted in universities through university-industry partnerships is a good example of the latter.

Networks can also be differentiated by their *geographical scope*. Thus, we can distinguish between local, regional, national, international and global networks. The *formality of network relationships* may also vary considerably from highly informal, flexible and trust-based relations toward more formal and rigid connections (Lundvall and Borrás 1997, 110). The *duration of network relationships* can also differ: for example, project teams or virtual corporations can be formed to achieve a particular short term goal, whereas strategic alliances, joint-ventures and business associations typically have longer term objectives. The new information and communication technologies have increasingly liberated networks from the need for physical proximity. Traditional social networks with face-to-face communication, we can conclude, have been supplemented by *virtual networks* and electronic interaction.

The boundary of a network can be more or less clear-cut. In most cases no clear boundaries between a network and its environment exist. It is not always easy to say whether a specific individual or organisation belongs to a particular network or not. The membership of a network can also change over time. Old members can leave, while new members can joint it. This means that networks are open constructs and we can speak of blurred boundaries. However, access to networks is not always easy and the costs of leaving a network can be quite high. We can therefore differentiate networks according to their *degree of openness or closeness*.

Networks can also differ according to the dimension of *centrality*. Networks are often defined as an association of autonomous social actors, which have equal rights. However, the dependency among the members of a network can be more or less symmetric. In some cases, a number of small companies can form a network of partners with equal rights and mutual assistance while, in other cases, the network may be led by one or more "flagship" firms which more or less control the other network partners (Rugman and D'Cruz 1996).

Finally, the *stability* of networks may also vary considerably. Networks are generally seen as a structure of loosely coupled actors, which makes it easy for new members to join them and for established partners to leave if they want. This could mean that the membership of networks would change quite rapidly and the relationships within them would be relatively unstable. However, in practice, networks are usually characterised by close interdependency and high-trust relationships among their members. Both factors contribute to the stability of network relationships. We can therefore characterise networks as stable and changeable at the same time.

When are networks efficient?

Networks are not always the most efficient arrangement for organising particular economic activities though their comparative advantage seems to have risen in recent years. The market mechanism and corporate hierarchies have their own organisational strengths and weaknesses, which give them a comparative advantage in some industry environments. In this section, we will examine the factors, which determine the relative efficiency of networks *vis-à-vis* markets and hierarchies. The following section will analyse the impact of these organisational arrangements on innovation processes and outcomes. Our analysis will focus on the three "ideal type" organisational alternatives in order to present our arguments and theory as clearly as possible. However, it must be realised that organisations often mix elements from the different ideal types in co-ordinating their activities.

The comparative advantages of markets, hierarchies and networks have been analysed in New Institutional Economics. This relatively new branch of economics

has applied the transaction cost theory (TCT) of Coase, Williamson and others to argue that economic activities are organised according to their transaction cost characteristics (Coase 1937; Williamson 1975, 1985). In particular, the TCT suggests that markets can efficiently organise economic activities whose relationships are characterised by low "asset specificity" and transaction costs. Hierarchies on the other hand, are superior with activities of high asset specificity and transaction costs, and networks or "hybrids" have a comparative advantage with activities characterised by intermediate levels of asset specificity and transaction costs (Williamson 1991). However, despite its considerable achievements, the TCT has met increasing criticism in recent years. The following arguments summarise the criticism from our perspective.

First, the TCT's definitions of "transaction" and "transaction cost" have been rather vague and all encompassing. Second, the TCT has paid disproportionate attention to transactions in comparison to production and coordination issues (Dunning 1988; Simon 1991; Demsetz 1991). As a result, the impact of firms' differential resources and organisational capabilities on organisational choices has not received sufficient attention (Conner 1991; Demsetz 1991). Third, the unit of analysis in the TCT is an individual transaction. This neglects the "external" costs and benefits that a particular transaction may cause in other parts of the interdependent production system (Stigler 1951; Chandler 1979;Porter 1985; Winter 1991; Simon 1991; Istvan 1992). Finally, the static approach of the TCT has little to say about the dynamics of technological and organisational innovation (Kogut and Zander 1992; Nahapiet and Ghoshal 1998; Lazonick 1993, 195).

The critics of the transaction cost theory have argued that firms make their organisational choices by comparing "all gains and losses" of alternative solutions (Chandler 1977; Dunning 1988; Contractor 1990; Demsetz 1991). Even if transaction costs are significant, organisational decisions may still turn on the similarity and synergies of firm's productive resources, its coordination costs, or the differing innovation capacities of organisational alternatives. Hence, we need to develop a richer theoretical framework of economic organisation.

In our framework, the comparative organisational advantage of markets, hierarchies and networks is determined by four characteristics of the value-adding system:

(a) similarity of resources and knowledge required by interdependent activities;
(b) level of transaction costs between such activities;
(c) coordination needs of interdependent activities; and
(d) nature of innovation processes.[62]

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[62] The focus of our framework will be on the economic determinants of organisation but we acknowledge that in some situations power motives may also play a role in organisational decisions. For a discussion of the relative merits of economic and power approaches to organisational analysis, see Perrow (1981), Williamson and Ouchi (1981), Francis, Turk and Willman (1983), and Williamson (1991).

Our key argument is that *all four organisational determinants influence organisational decisions.* Hence, partial theories, which neglect some important factors (such as the transaction cost theory), do not provide a satisfactory explanation of economic organisation. The relative importance of each determinant depends on the particular nature of the value-adding system and its context.[63] We will examine the first three organisational determinants in this section. The organisation of innovation will be analysed in the following one.

Many researchers have suggested that firms' resources and capabilities shape the organisational structure of value-adding systems (Richardson 1972; Miles and Snow 1986; Demsetz 1991; Kogut and Zander 1992; Quinn 1992). In their view, firms can only undertake activities and maintain organisational arrangements supported by superior firm-specific resources.

Similarity of resources and knowledge. The resource-based theory of the firm (RBT) became popular among strategy scholars in the late 1980s and early 1990s (Penrose 1959; Rumelt 1984; Wernerfelt 1984; Barney 1986; Teece et al. 1990; Peteraf 1993). The RBT looks at firms in terms of their unique bundle of resources. The resources that provide a firm's competitive advantage can take several forms: favourable location, proprietary technology and know-how, good reputation, superior organisational culture and routines, and so forth. In the early 1990s, the resource-based approach was applied to explain the boundaries of firms, particularly the limits to their diversification (Teece et al. 1990; Prahalad and Hamel 1990; Peteraf 1993). However, Richardson (1972) had applied the resource-based approach to organisational analysis already in the early 1970s.

Richardson (1972) analysed the organisation of industry with the concepts of *resource similarity* and *complementarity*. He argued that a firm's resources and capabilities support closely related, or similar, activities. In a specialised value-adding system, these activities must be co-ordinated with other, complementary, activities. Due to specialisation, the complementary activities are often undertaken by other firms possessing different kinds of resources (see also Miles and Snow 1986; Itami 1987; Demsetz 1991; Kogut and Zander 1992; Quinn 1992).

Although insightful, the resource-based theory neglects firms' transaction and coordination costs. Sometimes high transaction and coordination costs may overwhelm the resource- and knowledge-based advantages in organisational decisions. The RBT is also rather static: it emphasises firms' existing value-adding capabilities and production costs rather than their innovation capabilities and needs. The organisational determinants of innovation have been the focus of the more recent "knowledge-based theory of the firm" (see SMJ 1996). We will discuss the implications of this theory in the next section.

Transaction costs. Transaction costs are caused by the search of appropriate exchange partners, negotiation and enforcement of contracts with them, and the

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[63] Indeed, finding out the relative weight of each factor and the tradeoffs between them in particular contexts forms an important challenge for organizational research. In this chapter, we will take some initial steps into that direction.

problems of opportunism (e.g. adverse selection, moral hazard and principal-agent problems) related to the "bounded rationality" of economic agents. The transaction cost theory argues that transaction costs tend to increase with the "asset specificity" of value-adding activities (Williamson 1985). The more co-specialised the productive resources of interdependent value-adding activities, the higher will be the transaction costs of market exchange (Williamson 1985). After a certain threshold of asset specificity, the increasing transaction costs will begin favour "hybrids", or network arrangements, over market transactions. However, at the highest levels of asset specificity, only hierarchical solutions can efficiently reduce the behavioural uncertainties and transaction costs related to highly co-specialised resources (Williamson 1991).

Besides asset specificity transaction costs are also affected by the political and institutional framework within which the transactions are embedded (North 1990; Williamson 2000). Transaction costs are increased among other things by uncertain property rights and low trust among exchange partners. Different industries and local cultures may have widely differing institutional environments and transaction costs (see e.g. Fukuyama 1995).

Coordination costs. The coordination costs and mechanisms of value-adding systems are determined by the nature of interdependence among their different value-adding activities. The interdependencies are characterised by the "richness" of the required information flows among value-adding activities; more specifically, the number of specific aspects that must be co-ordinated between interdependent activities (Galbraith and Kay 1986; Daft and Lengel 1986; Simon 1991). A traditional market exchange involves only two *quantitative links*, price and quantity. However, interdependent value-adding activities often have *qualitative links,* which require the matching of specific operation plans (Richardson 1972; Simon 1991). For example, marketing, R&D and production functions may have to coordinate numerous aspects of their highly interdependent plans during a product development project (Kline and Rosenberg 1986; Teece 1992). The richer the information links between value activities, the more powerful coordination mechanisms are needed to facilitate the information exchange (Thompson 1967; Richardson 1972; Galbraith and Kay 1986; Daft and Lengel 1986; Simon 1991).

Thompson provides a useful typology of interdependence for our purposes by differentiating between the *pooled, sequential* and *reciprocal* relationships of hierarchically organised value-adding activities (Thompson 1967). In pooled interdependence, the value activities are interrelated only in that each activity contributes to the overall goal of the firm (e.g. firm's cafeteria and marketing department). In sequential interdependence, one value activity must be performed before the other (e.g. components manufacturing before their assembly). In reciprocal interdependence, value activities have feedback loops - i.e. they relate to each other as both inputs and outputs (marketing and R&D activities in dynamic industries) (Kline and Rosenberg 1986; Scott 1987). Van de Ven, Delbecq and Koenig have added a fourth type of interdependence to Thompson's typology, namely *team interdependence* (Van de Ven, Delbecq and Koenig 1976; Grant

1996). This is a systemic interdependence, which involves several reciprocal links within a group of economic agents.

Coordination of interdependent activities requires different mechanisms at different levels of interdependency and co-specialisation (Figure 1). In hierarchical organisation, pooled interdependence will be coordinated by *rules and standards*, sequential interdependence by *planning*, reciprocal interdependence by *mutual adjustment* (Thompson 1967), and team interdependence by *group meetings* (Grant 1996) and *shared understandings, values and visions* (Hämäläinen 2001).

If the interdependent activities are internalised by different organisations (low resource and knowledge similarity, low transaction costs) and the interdependence is of pooled nature, the activities will be coordinated by the *market mechanism* where price equates supply and demand quantities (Richardson 1972; Williamson 1985; Galbraith 1986). At higher levels of interdependence, firms will have to cooperate more closely to achieve qualitative coordination (Richardson 1972; Simon 1991). Similar to hierarchical organisation, sequential interdependence requires *cooperative planning*, reciprocal interdependence *mutual adjustment*, and team interdependence *network meetings* and the *development of shared understandings, values and visions* among the cooperating partners.

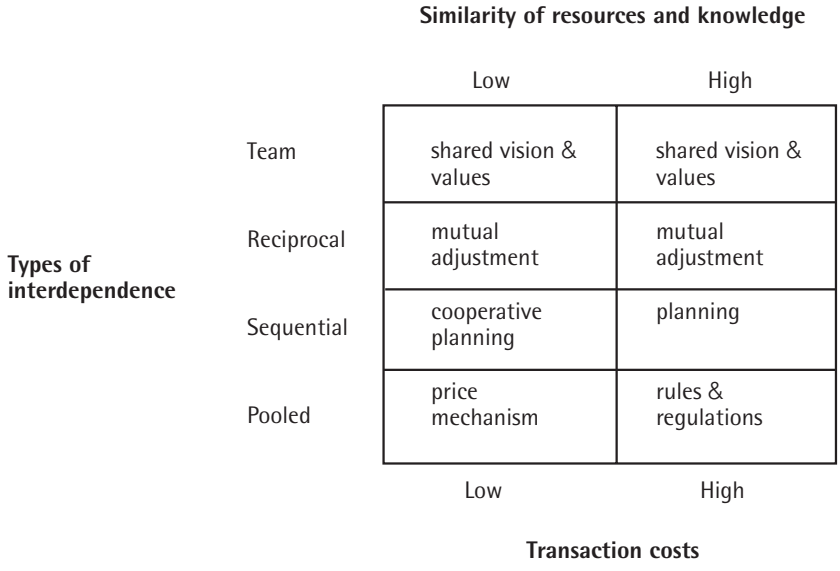

Figure 7. Coordination of interdependent activities.

In a competitive economy, firms will try to economise the use of different coordination mechanisms (Thompson 1967; Grant 1996). Coordination by rules, standards and the price mechanism requires least resources, particularly information

(Hayek 1945; Simon 1991). Thus the stronger and more resource-intensive forms of coordination - planning, mutual adjustment, group meetings and the development of shared understandings, values and visions — will only be used at the higher levels of interdependence (Thompson 1967).

At the highest levels of economic specialisation and uncertainty, top decision makers of large hierarchical organisations are challenged by the enormous information and knowledge requirements of co-ordinating highly interdependent value-adding systems (Hämäläinen and Laitamäki 1993; Hodgson 1999). These information and knowledge requirements can only be met by dividing and decentralising the coordination task to lower levels of the value-adding system. Such "semi-decomposable" sub-systems (Simon 1962) have the necessary knowledge of the "particular circumstances of time and place" (Hayek 1945). The overall coordination of the value system must now take place through shared understandings, visions and values.

By focusing the organisation on its "core competencies" and activities, hierarchical coordination problems can also be reduced (Prahalad and Hamel 1990). This kind of specialisation is usually associated with the externalisation of some "non-core" activities to related organisations. The resulting smaller hierarchy is easier to coordinate than a large diversified one. To sum up, increasing coordination problems will lead to the use of stronger and more horizontal coordination mechanisms, decentralisation of hierarchies and the growth of inter-organisational networks.[64]

Although important, the three efficiency-related determinants of organisation are not the only ones. In dynamic industries, organisational decisions are influenced by innovation considerations. Markets, hierarchies and networks provide quite different contexts for innovation processes.

When are networks innovative?

Since the seminal work of Schumpeter (1942), innovation researchers have recognised that organisational arrangements have an important impact on modern innovation processes. This impact cannot be ignored in a world of increasing innovation competition and quickly eroding resource and cost advantages. Moreover, the importance of innovation to organisation is likely to vary among industries. It is likely to play an important role in the organisation of high-tech industries; while the resource and cost considerations will receive more attention in the more mature industries.

[64] The destruction of large hierarchical organisations in the US computer industry during the 1990s provides a good example of these trends (Hämäläinen and Laitamäki 1993).

The organisational determinants of innovation and learning have recently been studied by scholars developing the new "knowledge-based theory of the firm" (KBT) (see e.g. Cohen and Sproull 1995; SMJ 1996, Nahapiet and Ghoshal 1998). Kogut and Zander even define a firm as "a social community specialising in the speed and efficiency in the creation and transfer of knowledge" (1996, 503).

The KBT analyses the different types of knowledge carefully. Particularly, the different implications of *tacit* (implicit) and *codified* (explicit) knowledge for competitiveness, communication, information systems and organizations have received a great deal of attention (see e.g. Kogut and Zander 1992; Nonaka and Takeuchi 1995; Spender 1996 ; Brown and Duguid 2000). For example, Spender has argued that sustainable competitive advantage can best be built on socially shared and tacit knowledge (Spender 1996). Nonaka and Takeuchi have emphasised the dynamic interaction between an organisation's tacit and codified knowledge bases for the development of new knowledge (Nonaka and Takeuchi 1995). Daft and Lengel, in turn, have underlined the importance of informal face-to-face communication mechanisms in highly complex and uncertain situations where the established cognitive frames must be changed (Daft and Lengel 1986).

The knowledge-based theory of the firm emphasises four organisational factors, which influence the innovativeness of firms. These are *diversity of knowledge, intensity of communication, availability of complementary assets, and social capital*. We will discuss the first three factors in this section. Social capital will be analysed in the following section because it influences all four determinants organisation.

The principal way of advancing social and scientific knowledge is through *new combinations* of existing knowledge sets. An exchange is a prerequisite for a combination in which knowledge is held by different individuals. The new combinations may be created by exchanging and combining different types of knowledge or by combining the same knowledge elements in a new way (Grant 1996; Nahapiet and Ghoshal 1998).

Historically, the new combination of knowledge took place in the heads of single inventors such as Leonardo da Vinci, Thomas Edison and Albert Einstein. The inventiveness of such "hero inventors" was often facilitated by their varied background and training which gave them the required diversity of knowledge and cognitive frame as well as the mental flexibility to combine different types of knowledge or to create new combinations of old knowledge elements.[65] However, today, individual knowledge sets tend to be so specialised that the required diversity of knowledge for major innovations can only be reached when two or more experts combine their different knowledge sets and create a new, partially shared knowledge base (Grant 1996).

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[65] Hollingsworth pointed out recently that the "cultural diversity within one's head" was an important factor behind major scientific breakthroughs in his empirical studies (Hollingsworth 2000). Such diversity and mental flexibility could be facilitated by an education system, which familiarised students with many different subjects, disciplines and perspectives.

The knowledge of different individuals cannot be exchanged, combined and shared very easily. The first prerequisite for combination is the individuals' access to each other, a membership in the same community, for example. The combination also requires the development of a common cognitive frame, shared language, overlapping knowledge structures (absorptive capacity) and a meta-level recognition of each other's knowledge domains (Nahapiet and Ghoshal 1998). The combination and reframing process involves both codified and tacit knowledge, the latter being very difficult to communicate. However, once established, the shared frame, knowledge base and language permit individuals to exchange and combine aspects of knowledge which are not common between them (Grant 1996). This provides new insights, perspectives and meanings, which would not otherwise emerge.

The development of shared knowledge bases among individuals with different knowledge sets requires intensive and long-term communication. The more diverse the individuals' knowledge sets are initially, the more difficult such communication becomes. At one extreme, when the individuals' knowledge bases are totally different, communication, and hence the creation of shared knowledge, becomes impossible. On the other hand, when the knowledge sets are very similar both communication and the creation of shared knowledge are very easy. However, the low diversity of knowledge does not encourage learning and invention.

As shown in Figure 8, the relationship between knowledge diversity, intensity of communication and inventiveness (knowledge creation) tends to take the shape of an inverted U (Nahapiet and Ghoshal 1998; Hollingsworth 2000). The intermediate levels of knowledge diversity, where the combination of different knowledge sets is still possible, provide the most fertile ground for major inventions. Moreover, the "radicality of innovations" can be expected to grow with the diversity of knowledge combined (Nahapiet and Ghoshal 1998).

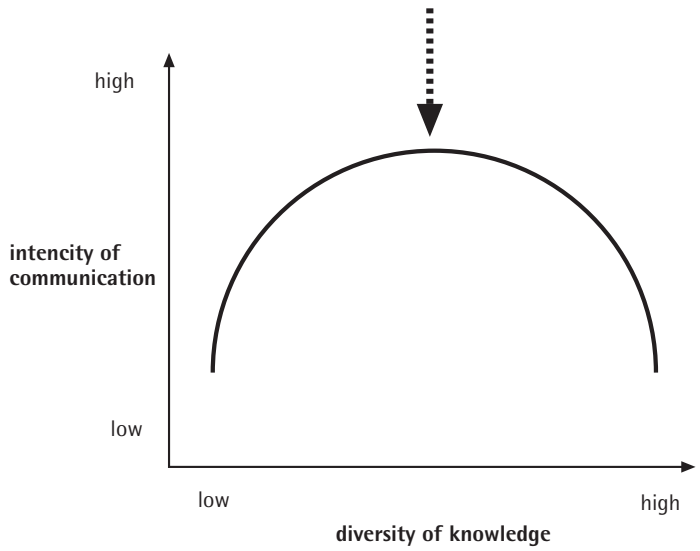

Figure 8. Point of maximum inventiveness. (Source: Hollingsworth 2000.)

Finally, the initial inventions do not turn into successful innovations before they are combined with many different complementary assets and activities and brought to the market (Teece 1987). This may require "systemic innovation" where the missing pieces of the idea-innovation chain are either acquired or created or other value-adding activities are adjusted to the demands of the new invention. The initial invention may involve any part of the value-adding system (sourcing, technology, production, marketing, etc.); the systemic innovation takes place in the other, complementary, parts of the system.

Nahapiet and Ghoshal argue that the intensive communication required for creating new innovations cannot take place through the market mechanism (Nahapiet and Ghoshal 1998). According to them, rich communication flows require hierarchical organisation. This is consistent with Brown and Duguid who note that new knowledge is typically created in closely interacting "communities of practice" which have a shared frame, professional code and knowledge base. Small firms may only have one community of practice; larger firms may have several functionally divided communities (Brown and Duguid 1991, 1999).

The diversity of knowledge and other resources may not be adequate for major innovations within highly specialised organisations, however. Often the necessary co-specialised assets can only be found in other organisations. Since markets do not support intensive inter-organisational communication, networks become a natural organisational arrangement for innovative processes in these kinds of environments.

An organisation's access to the diverse knowledge and resource base of occupational "networks of practice" may become a particularly valuable asset for its innovation processes (Brown and Duguid 1999). Such horizontal networks consist of experts who are engaged in similar activities in different organisations. Their knowledge bases, frames and language overlap to a larger or smaller extent. As a result, networks of practice can provide an attractive continuum of knowledge and resource diversity and combinative capability for innovative activities.

The previous two sections have argued that all four organisational determinants play an important role in organisational decisions. However, the four determinants do not always lead to same organisational conclusions. Organisational decision making involves important tradeoffs between the different determinants.

In practice, the existence of organisational tradeoffs has led to the development of "hybrid" organisations, which attempt to combine the best features different "ideal types". For example, the traditional hierarchical "machine bureaucracy" with its rigid top-down command culture and alienated employees cannot easily be found in modern business world. Most large corporations have introduced various horizontal coordination mechanisms, employee involvement programmes, flexible decision-making procedures, corporate visions, cultures and values, and so forth. Large hierarchies also tend to be active participants and cooperation partners in numerous external networks. They also use markets for acquiring more standardised inputs and raw materials. Hence, the organisation of complex value-adding systems tends to involve markets, hierarchies and networks in different combinations and mixes.

Why have networks become so important in recent years?

The world economy is currently going through a major transformation driven by the globalisation of markets and the rapid development of the new ICTs. The four determinants of economic organisation have been fundamentally influenced by this paradigm shift. As a result, network arrangements have increased their comparative advantage in economic organisation relative to markets and hierarchies.

Despite the growing importance of information networks, the modern ICTs are *not* a major explanatory factor in the emergence of the network paradigm. ICTs have made all organisational alternatives more efficient; they have not favoured any particular organisational arrangement over the others. Markets have clearly become more efficient as more information can be accessed and processed more easily. This is particularly evident for simple and standardised goods whose product attributes are well-known to all market participants (financial instruments, raw materials, standard consumption goods). However, these goods were traded in markets already before the recent information revolution.

Hierarchies and networks have also benefited from easier information processing and communication. Large multinational corporations have been able to locate their specialised activities to the most attractive locations around the world and coordinate them tightly with the new ICTs. Also, networks of firms and other interdependent organisations increasingly use the ICTs to jointly optimise their operations. Hence, the growing importance of network arrangements cannot easily be explained with the new ICTs.

Two other features of the current paradigm shift seem to offer a much better explanation for the growing importance of networks. The *growing specialisation and uncertainty of economic activities* has increased the comparative advantage of networks in economic organisation. This section will analyse the impact of these twin forces on the four organisational determinants discussed in previous sections.

Similarity of resources. The growing specialisation of productive activities has led to increasingly specialised and dissimilar resources and knowledge in value-adding systems. In terms of the transaction cost theory, the "asset specificity" of value-adding systems has increased (Williamson 1985). As firms focus on their "core competencies", they tend to develop closely-related (similar) resources and capabilities internally and rely on cooperative ventures (networks) for the acquisition of more distant (dissimilar) but co-specialised resources (Kogut and Zander 1992). The growing uncertainty of economic activities has also emphasised the need for networking by making the organisations' future core resources and knowledge less certain. Particularly in high-tech industries, large corporations have formed numerous strategic alliances with small high-tech firms to get an "option" to their potentially valuable resources and knowledge.

Transaction costs. It has often been argued that the rapid development of ICTs has reduced the transaction costs of economic activities and thus made the market mechanism more efficient in recent years (e.g. Economist 1996). However, recent changes in the efficiency of markets depend on the types of goods and markets analysed. The greatest beneficiaries of modern ICTs have been markets for simple and standardised goods, such as financial instruments, raw materials and commodities. These types of markets have clearly become more efficient with the new ICTs.

On the other hand, many service markets (such as personal services, training, etc.) and most markets for technology-intensive and highly-specialised intermediate products and services (tailor-made parts and other inputs, management consulting, advertising, etc.) involve rich information flows which are difficult to codify for the modern ICTs. More importantly, the dynamic forces of the world economy have increased the transaction costs of markets.

First, the growing specialisation of economic activities has led to increasing asset specificity, knowledge diversity and information asymmetry among economic agents (Williamson 1985, Hodgson 1999). Second, the increasing division of labour has reduced the impact of shared ideologies and values on individual and firm behaviour (Durkheim 1893, reprinted 1964). This tends to undermine trust and other social constraints to opportunistic behaviour (North 1981; Casson 1990). Third, the increasing specialisation and differentiation of firms' resources and buyers' preferences has led to a proliferation of new products and product attributes in the market place. This has increased the search, measurement and enforcement costs of boundedly rational economic agents (Piore and Sabel 1984; Willinger and Zuscovitch 1988; Eliasson 1990).

Fourth, the bounded rationality of economic agents has been further challenged by the information exploitation related to the globalisation of markets. The firms' exposure to new types of customers, competitors, institutions, and cultures creates new types of information needs and uncertainties, which cannot properly be dealt with in contractual exchange. It is well known that the transaction costs of international business activities are greater than those in purely domestic markets (Buckley and Casson 1976; Hennart 1982). Finally, the rapidly growing markets for information and knowledge products involve more uncertainty and transaction costs than markets for more traditional goods and services (Arrow 1962).

To sum up, the transaction costs of value-adding activities have been influenced by two opposing forces. The new information technologies have reduced the transaction costs of markets for simple and standardised goods, whereas increasing economic specialisation and uncertainty have increased the transaction costs of markets for more specialised, differentiated, complex and knowledge-intensive products. As a consequence, the markets for the former types of goods have become more efficient in recent years; while those for the latter types of goods have become less efficient. The growing transaction costs have increased the competitive advantage of networks and hierarchical organisations relative to markets in highly specialised and uncertain industries (Hämäläinen 1993). In such industries,

high transaction cost activities would require hierarchical organisation, while those that involve intermediate levels of transaction costs could be coordinated through cooperative networks (Williamson 1991).

Coordination costs. The coordination costs of value-adding systems have also been increased by the growing specialisation and uncertainty of economic activities. The growing specialisation increases the coordination costs of value-adding systems by multiplying the number of activities that must be co-ordinated and increasing the specificity and richness of information links between them (Hämäläinen 1993). The coordination of highly co-specific activities requires large information flows and effective communications media between the interdependent activities (Daft and Lengel 1986). The costs of communication, in turn, are increased by the growing diversity of individual knowledge sets and frames. As we have seen in Figure 7, the increasing specialisation and interdependence of value activities requires more effective and costly coordination mechanisms. These mechanisms can be used in both hierarchies and networks.

We have argued earlier in this chapter that hierarchical coordination becomes problematic at the highest levels economic specialisation. The coordination tasks of top management can exceed their coordination capabilities, which rapidly increases the coordination costs. As Kaldor (1934) and Robinson (1934) noted long time ago, the increasing coordination costs reflect the limited mental capabilities of top managers and the indivisibility of the coordination task (Robinson 1934, 248).

Robinson (1934, 253) has argued that hierarchical organisation can be extended indefinitely without a loss of efficiency only on two assumptions. First, that the necessary knowledge for decisions is small, and second, that the maximum amount of coordination is achieved at each level of the organisation, and the knowledge required for coordination at the next higher level need not descend into the lower levels. In managerial practice, neither of these assumptions is likely to hold (Robinson 1934, 254).

Over time, innovations in information technology, organisation and accounting systems have alleviated the managerial coordination task by improving the quality and increasing the amount of available information, creating special organisational units to process part of the information (staff, consultants), developing new organisational forms (functional and multi-divisional structure), and by introducing new accounting concepts to synthesise information (stockturn, operating ratio, rate of return, current ratio) (Kaldor 1934; Chandler 1977, 1979). However, these innovations have only provided temporary solutions to the growing coordination problems of large, complex and dynamic organisations.

The nature of the coordination challenge is also influenced by the amount of environmental change. Kaldor (1934) has argued that organisations can become larger in "quiet" periods when environmental change is less rapid. One such period of relative environmental "quietness" was experienced during the decades immediately following the Second World War (Piore and Sabel 1984). The seemingly unstoppable growth of large hierarchies during this period led some researchers to

doubt the practical effectiveness of the coordination cost limit to the growth of hierarchical organisations (Penrose 1959, 18). However, the growing specialisation and uncertainty of modern value-adding systems has re-emphasised the "managerial limit" to organisational growth during the past two decades.

As we have argued, the increasing coordination costs tend to favour decentralised organisational solutions, which economise in the scarce coordination capability of individuals by dividing the overall coordination task into more manageable parts. To a certain extent, this decentralisation can take place within hierarchical organisations through divisionalised structures and improved accounting procedures (Chandler 1979). The divisional structure divides the coordination and supervisory tasks of management into semi-decomposable units, which maximises the coordination capability of the top management team. However, the hierarchical solutions to coordination problems are limited.

At some point, the further growth of hierarchical organisation will be limited by the increasing coordination costs related to the bounded rationality of the management (Kaldor 1934; Robinson 1934; Simon 1991). The growing size of the hierarchy also magnifies the agency problems, organisational politics, splintering of ideologies, bureaucratic alienation, and loss of information, which increase the monitoring and supervision costs (Williamson 1975). This is where the benefits of decentralised information processing and coordination within networks of closely cooperating firms overwhelm the additional costs of inter-firm communication and coordination (Hämäläinen and Laitamäki 1993).

Innovation. The increasing specialisation and uncertainty of economic activities has shaped the comparative efficiency of organisational arrangements also through their impact on innovation processes.

We have argued above that major inventions tend to take place when different types of knowledge are exchanged and combined. The growing specialisation on "core activities" has reduced the diversity of knowledge within organisations. The required complementary resources and knowledge cannot often be found within the boundaries of a single firm.[66] Hence, innovation processes increasingly demand inter-firm cooperation and networking.

In a highly specialised system, the complementary resources and knowledge are also likely to be highly specialised. Such highly specialised resources and knowledge cannot always be found in the innovating organisation's home location but needs to be searched from other locations in the same region, country or even from abroad. Narula and Dunning (1998) note the rapid growth of international strategic technology partnerships (STPs) during the past two decades. They explain this growth primarily with the firms' innovation needs: STPs are an efficient way of combining the firms' different knowledge bases.

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[66] The number of potential combinations of different elements of knowledge grows very rapidly when the number of elements is increased. As a result, networks which involve more diverse elements of knowledge than hierarchies have a substantially wider potential for innovative combinations.

We have also noted that the exchange and combination of different knowledge sets requires intensive long-term communications, shared language, as well as overlapping cognitive frames. The growing specialisation of value-adding activities has led to increasingly diverse experiences among individuals, splintering of their cognitive frames and differentiation of language. Nahapiet and Ghoshal suggest that these communication problems can be better resisted within corporate hierarchies than in firms coordinating their activities through arm's length markets (Nahapiet and Ghoshal 1998). However, high-trust networks can also support the rich communication flows needed for exchanging and combining diverse knowledge sets.

In conclusion, individual organisations cannot usually be very successful innovators in highly specialised and uncertain industries, no matter how big they are. Instead, the most fertile environment for innovation tends to involve a large network of economic agents who can engage in intensive, long-term communication (see Hyötyläinen 2000).

In this section, we have argued that the growing specialisation and uncertainty of economic activities has increased the comparative advantage of networks arrangements *vis-à-vis* markets and hierarchies. In the highly specialised and uncertain environment, networks allow deeper economic specialisation than hierarchies, reduce transaction costs relative to markets and coordination costs relative to hierarchies, and provide the most fertile ground for innovation. In the modern world economy, network cooperation is often the most efficient and innovative organisational arrangement.

Social capital and networks

Earlier in this chapter, we suggested that organisational arrangements are influenced by certain cultural factors surrounding organizations, often grouped under the term "social capital". This term is somewhat misleading because "capital" has traditionally referred to as a productive input. As we will see in this section, social capital describes the *social context* in which productive inputs are organised and used. We will analyse the different characteristics of social capital, how it affects economic organisations and performance, the mechanisms through which it accumulates, and why it has become so important in recent years.

There are various definitions of social capital, but they all emphasise the social relationships and norms among individuals, their ability to cooperate and the resources that can be mobilised through such cooperation (Fukuyama 1995; Nahapiet and Ghoshal 1998). In this section we will use the more refined definition of Nahapiet and Ghoshal who distinguish between three dimensions of social

capital: *structural, relational and cognitive.*

The structural dimension describes the overall configuration of linkages among people (network ties). These linkages can be measured in terms of their density, connectivity, redundancy and hierarchy. The relational dimension describes the kinds of personal relationships and behavioural norms people have developed with each other through a history of interactions. Such relationships are characterised by friendship, respect, trust, obligations, and identity, for example. The cognitive dimension refers to shared understandings, mental frames, language, narratives and meanings among a group of individuals. Social capital as we can see is jointly owned by the parties involved in a relationship. Since it can yield both private and public benefits it has public good characteristics (Kajanoja 1999; Woolcock 2000).

There are also differences in the *strength* and *scope* of social capital. The strongest type of social capital can usually be found among family members. This is the dominant form of social capital in many Asian societies (Fukuyama 1995). Social capital can also be found among members of social associations (such as sports clubs, religious groups, lions clubs, rotaries, etc.) and other groups with shared experiences (school and university friends, colleagues at work, etc.). The American society is famous for its "art of association", though some observers have become concerned about its future (Fukuyama 1995; Putnam 2000). Compared to core family relationships, these associational relationships tend to be somewhat weaker but usually more numerous. Finally, societies also tend to share some social capital at the regional and national levels. A common language, history, living environment, primary education system and mass media are forces that build this type of "cultural" social capital. The Nordic countries provide a good example of relative homogenous, "high-trust" cultures.

The amount of social capital in a society has important influence on its economic performance. Coleman showed that the amount of social capital in families and neighbourhoods had an important impact on the creation of human capital in the United States (1988). According to Putnam, social capital could also explain the differences in economic performance among Italian regions (1993). North, in turn, has shown how the institutional framework of societies has been an important determinant of their economic performance throughout economic history (1990). North's definition of "informal institutions" corresponds to an important part of relational social capital; it includes the culturally embedded norms, customs, traditions, conventions, customs, sanctions, and codes of conduct.[67]

The economic analyses of social capital have focused primarily on its transaction cost reducing properties (see e.g. Casson 1990; Fukuyama 1995). However, the economic impact of social capital is much wider and more important. It shapes all

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[67] More recently, the World Bank has begun to study the impact of social capital on economic development and growth (Woolcock 2000).

of our four determinants of economic organisation: specialisation, transaction and coordination costs, and innovation.

First, high degree of economic specialisation is not possible without social capital. As we have seen, specialisation and division of labour create interdependencies and uncertainty by exposing economic agents to the behaviour of their exchange partners. The uncertainty of such relationships is greatly reduced by strong relational and cognitive social capital (trust, norms, reciprocity, and shared frames). This is also the reason for the lower transaction costs in "high-trust" societies (Casson 1990; Fukuyama 1995). The lower transaction costs, in turn, make markets and network arrangements more efficient.

High levels of social capital also tend to reduce coordination costs in value-adding systems. Shared behavioural norms reduce the information processing needs of individuals as they can take certain behaviours of others for granted and the same norms guide their own behaviour toward socially acceptable ends. Perhaps more importantly, the effectiveness of the stronger coordination mechanisms is highly dependent on social capital. The size and structure of an individual's network of personal relationships shapes his information about systemic coordination needs (Nahapiet and Ghoshal 1998). Strong relational and cognitive social capital, in turn, facilitates horizontal cooperation, mutual adjustment, and the creation of shared visions, understandings, values and strategies.

Besides facilitating economic specialisation and reducing transaction and coordination costs, social capital has a positive impact on the innovation processes. Large inter-personal networks increase the diversity of knowledge available to individuals. The relational part of social capital influences the access of individuals to different sources of complementary knowledge and their motivation to exchange it. Finally, a shared language and cognitive frame support the intensive communication required for combining different knowledge sets. Hence, the social capital shapes the individuals' "combinative capabilities" (Kogut and Zander 1992).

The amount of social capital in an economic system, we can conclude, will not only influence its transaction costs, but also its productivity (through specialization), coordination costs and innovativeness. Hence, social capital is a fundamental determinant of economic performance at the level of value-adding systems, industries, regions and even nations (Casson 1990; Putnam 1993; Fukuyama 1995**).** Moreover, as we will show below, its role in value-adding systems has become even more important in recent years.

However, the economic impact of social capital is not always positive. Particularly during major paradigm shifts, strong social capital can cause mental and behavioural rigidities among decision makers which may prevent the necessary organisational and institutional adjustments to changing environmental conditions (Nahapiet and Ghoshal 1998; Hämäläinen 2001). A strongly shared cognitive frame and language can make individuals insensitive to contradictory information and totally new perspectives (Festinger 1957). Strong inter-personal relations, in turn, can make individuals unwilling to take new actions, which could harm well-established interests in the society (Olson 1982). During the past decade, the inability of the Japanese society to renew its post-war institutional structures despite a prolonged

recession has provided an interesting example of this type of situation.[68]

The social capital has to be *relevant* to the changing needs of the economy in order to have a positive impact on economic performance. Rapidly changing environment can make previously beneficial social capital economically irrelevant or even counter-productive, and *vice versa*. Streeck gives the example of Northern Italy whose small artisanal family firms embedded in dense family ties and local networks of parties, unions, and employers' associations were deplored as a sign of backwardness in the 1960s. These same firms came to be regarded as a principal source of the region's suddenly impressive competitive performance in the 1970s and 1980s when the technological and market environment changed (Streeck 1997, 211).

The fact that social capital has such an important effect on economic efficiency and innovation raises the question: how does it develop? And from a policy perspective, how could social capital be built and renewed? Based on their extensive review of the literature on social capital, Nahapiet and Ghoshal conclude that the development of social capital is significantly affected by factors that shape the evolution of social relationships: *interaction, time, interdependence, closure,* and *co-location* (Nahapiet and Ghoshal 1998).

Social capital develops in the interaction of individuals. Social interaction and communication build all three dimensions of social capital: structural, relational and cognitive. Interactions with previously unknown individuals leads to the building of social networks, while continuous interactions within established contacts accumulates relational and cognitive social capital. Without continuous interaction, social capital begins to decay (Bourdieu 1986, 250).

The development of relational and cognitive dimensions of social capital requires *long-term* interaction and shared experiences. It takes time to build trust and a shared frame among individuals who have not previously known each other. Usually, such long-term relationships have not been designed for the creation of social capital, it accumulates as a by-product of other activities. However, policy makers can facilitate the creation of social capital by bringing people together in meaningful long-term interaction and cooperation.

As Durkheim noted long time ago, the relational part of social capital is shaped by the degree of specialisation and interdependence among people (Durkheim 1893, reprinted 1964). High levels of interdependence both build and require high levels of trust, mutual obligations, and shared expectations among individuals. On the other hand, social capital is eroded by factors which make people less dependent on each other (Coleman 1990). Furthermore, the development of shared norms, identity, trust, and language are facilitated by community separation and network closure.

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[68] Woolcock suggests that the negative consequences of strong social capital can be reduced by an appropriate balance between the "intra-community ties" and "extra-community networks"; in our terminology, the structural dimension of social capital on the one hand, and the relational and cognitive dimensions on the other (Woolcock 2000).

Finally, the creation of relational and cognitive social capital tends to require co-presence and co-location. Building trust and shared understandings requires a long period of rich communication and active interaction, which is difficult to achieve, if people are not located closely to each other. Modern ICTs cannot overcome the need for face-to-face communication in complex learning and re-framing processes (Daft and Lengel 1986; Bierly and Hämäläinen 1995). Telecommunication can only complement face-to-face communication in such processes (Woolcock 2000).

The determinants of social capital limit the institutional contexts in which it can be accumulated. The natural bases for long-term and relatively closed interaction characterised by high level of interdependence and co-location are: *families, neighbourhoods, workplaces, schools, universities, military service and social associations.* More temporary relationships, such as holiday or conference trips, business projects or training courses, can also build social capital among their participants.

The different organisational arrangements have particular relationships to social capital. Market relastionships are not conducive to the creation of social capital (Nahapiet and Ghoshal 1998). These relationships tend to be temporary, impersonal, loose, and dynamic. None of these characteristics facilitates the development of social capital. However, markets are dependent on social capital. As we have seen, economic specialisation and market transactions are greatly facilitated by social capital. Nahapiet and Ghoshal (1998) argue that organisations have a special advantage in the creation of social capital. They facilitate long-term interaction, interdependence, closure and co-location. Hence, organisations are better environments for innovation and learning than markets.

In their capacity to accumulate social capital, networks fall somewhere in between markets and hierarchies. They clearly foster more interaction and closer interdependence among agents than markets; but their inter-personal relationships are usually somewhat looser, more temporary and open than those in hierarchical organisations. As a result, the functioning of networks is dependent on *external* sources of social capital. This may explain why the interest in social capital has increased in tandem with the rise of the network paradigm. We will return to this topic below.

It is important to note that the members of a particular culture may share some social capital though their relationships do not necessarily meet the above criteria of long-term interaction, interdependence, closure and co-location. If the members of a culture are sufficiently homogenous in their historical experiences, educational background, living and working conditions, and media consumption they can extend the relational and cognitive dimensions of social capital also to those members of the culture whom they have not met before. Thus, people may, to a certain extent, trust and understand members of their own culture even without long-term experience of their behaviour and thoughts. Such "cultural social capital" is particularly evident in "high-trust" societies such as Finland and

Japan (Casson 1990). Culturally heterogeneous societies must rely more on the other sources and types of social capital (Fukuyama 1995).[69]

Social capital has often been used as an argument to defend the traditional welfare state with its large income transfers and strong social security net. In its simplest form, this argument has equated small income differences, lack of social conflict and low crime rates with strong social capital. Although the welfare state may build some cultural social capital by promoting these socially desirable ends, it does *not* seem to play a key role in the creation of structural, relational and cognitive social capital. In fact, it may even have weakened the latter types of social capital by shifting a large part of the traditional social responsibility of families, neighbours, friends, colleagues and local community members to the public sector (Fukuyama 1999). Hence, it seems that the role of the welfare state in the development of social capital has been exaggerated in the public discourse.[70]

Social scientists and policy makers from various sectors have become increasingly interested in the concept of social capital during the past decade (Woolcock 2000). The growing interest in social capital is closely related to the current transformation in the world economy. First, as we have seen, cooperative networks have become increasingly efficient and innovative *vis-à-vis* markets and hierarchies. However, networks cannot themselves create all the social capital necessary for their success. They need to be embedded in social capital produced outside the network.[71] Thus, the emergence of the network paradigm has increased the demand for social capital, particularly in comparison to the old hierarchical paradigm. The efficiency and innovation advantages of networks cannot be reached without sufficient social capital.

The other main factor behind the growing interest in social capital is related to its diminishing supply in advanced economies. The current paradigm shift has changed the nature of work and individual values in ways that have led to a decay of many traditional sources of social capital (Fukuyama 1999; Putnam 2000). The growing specialisation of work has produced increasingly differentiated work experiences and cognitive frames among workers. Unlike the agricultural work of the pre-industrial era, or the simple factory work of the industrial one, the modern, highly differentiated working life offers very few widely shared experiences that could form the basis for common understandings, norms and identity.

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[69] A fresh study by Alesina and La Ferrara (2001) using U.S. data shows that blacks and members of racially mixed communities were far less likely to trust others than were whites or others living in racially homogenous communities.

[70] Our analysis suggests that *network-facilitating* and *community-building* policies could be a more direct way to support the creation of social capital.

[71] Miettinen et al. (1999) provide examples of major Finnish innovations where the key individuals in the innovation networks had learnt to know and trust each other long before they started to cooperate on the innovation. The close relationships were not built for the network, instead, the network could utilize the social capital built much earlier. Hence, the development and accumulation of social capital may have unpredictable consequences years or even decades later.

The techno-economic paradigm shift has also changed the nature of employment relationships. A surprisingly large and growing fraction of the labour force works in "contingent" or "non-standard" jobs: part-time, temps, independent contractors (consultants), "on-call" workers (substitute teachers, rush hour help, etc.), and the like (Putnam 2000; Suikkanen et al. 2001). As Putnam notes, the instability of jobs has weakened the social capital at work places. Building social relationships takes time and requires stable contacts.

At the same time, the growing pressures of modern knowledge-intensive work are reducing the amount of social capital built in families. Knowledge workers are working longer hours and often continue to work at their homes. This reduces the time available for socialisation with family members, relatives and friends. Moreover, even when they do not work at home, knowledge workers can be "mentally absent", thinking about some work-related concerns. The knowledge work cannot easily be "turned off" from the brain in the end of the working day as traditional factory work could. As a result, knowledge workers spend less time with their spouses, children, relatives, friends and associates than people used to do in the past when working life was less hectic. This may partially explain the rising divorce rates in Western societies, the increasing development problems of children, the weakening ties among relatives and friends, and the declining participation in social associations. These negative trends diminish social capital in advanced societies (see Fukuyama 1999; Putnam 2000).

The increasing pressures of knowledge work are not the only factor taking time from established social relationships. The past few decades have seen the rise of individualistic values in advanced societies (Inglehart 1977; Putnam 2000). The rapid accumulation of wealth during the post-war decades has pushed a large part of the population in industrialised countries to income levels where their basic needs have already been met. From a Maslowian perspective, the rising individualism, or even selfishness, is related to the growing importance of self-actualisation needs in the society. Wealthy individuals are actively pursuing their favourite hobbies and leisure activities, often at the expense of the time spent with their families, relatives, old friends and associates. Moreover, the new leisure activities tend to be more individualistic than the activities of the industrial society (Putnam 2000). Hence, they do not generate social capital in the way the more social leisure activities of the past did.

There is one more mega-trend, which is diminishing the supply of social capital in industrialised societies. The current paradigm shift has led to a geographical concentration of economic activities (Hämäläinen 2001). As a result, a large number of workers have been forced to move after jobs to the new growth poles of the global economy. They have left behind their established social networks and it takes a long time to build similar relationships in the new location.

In summary, the economic importance of social capital has increased in recent years due the demands of the new network paradigm and the diminishing supply of social capital in families, among relatives and friends, and in social associations. The social capital has become the scarce resource in economic organisation and performance.

Network failures

The comparative organisational advantage of markets, hierarchies, networks and governments depends on their relative strengths and weaknesses in particular contexts. The pros and cons of markets, hierarchies and governments have been thoroughly analysed by economists, management scholars, and political scientists. Hence, "market failures", "bureaucratic failures" and "government failures" are well-established terms in their literature. This chapter has focused on the comparative advantages of networks in economic organisation. In the end, it is appropriate to discuss the potential weaknesses of network arrangements, or "network failures". This area of organisational analysis has been neglected even by most network research.

First, a word of clarification is needed. "Network failures" must be distinguished from "failures in networking". The latter refer to special problems in setting up networks. They will be discussed in Chapter Ten. Network failures, in turn, cause existing networks to fail or perform below their potential. We will focus on the problems of already existing networks in this section.

Networks may become inefficient if their environment changes dramatically and calls for large systemic adjustments in the network. Since networks involve multiple partners with diverse interests it can be *difficult to achieve swift and well-co-ordinated adjustments* in the system. Some partners may favour more rapid or other types of adjustments than others and the negotiation processes may delay the necessary action.

Large network-specific investments and close interdependency can make network partners conservative and risk averse because rapid change can cause unintended and unpredictable negative consequences. As we argued with social capital, this problem will further slow down systemic adjustments and maybe even create *technological and structural "lock-ins".*

Networks are also *vulnerable to conflicts*. Network cooperation requires continuous negotiation and mutual adjustment, which may lead to conflict if systemic tradeoffs cannot be properly solved. Networks produce economic benefits and involve tangible costs, which have to be allocated among its members. There is no predetermined formula for doing this.

Conflicts among network partners can be related be *asymmetric power relationships.* If the leading organisation in the network misuses its powerful position it may undermine the social capital among partners. Trust, reciprocity and fairness are key characteristics of well-functioning networks. On the other hand, some partners may also *freeride* the network building investments and activities of leading organisations. The freeriders reap the benefits of cooperation but do not contribute their fair share in the network's operating costs. This will also diminish the social capital underlying the network.

Over time, established networks will create internal routines, conventions and rules, which facilitate their day-to-day operation. These internal "institutions" may begin to *insulate the network from other organisations,* which are not embedded in them. As a result, the network may become "fossilised" and more or less closed from the outside world, particularly potential new partners. Sometimes such closure may even be planned so as to exclude some organisations from the network. Some of the social benefits of networking are, of course, lost in such isolation.

It is important to note that all of the above network failures are related to *problems with social capital.* First, as we have argued before, the coordination of complex systems is supported by strong social capital. Hence, the scarcity of social capital will cause coordination problems. A small network of partners will limit the available coordination information and weak relational and cognitive social capital will make horizontal cooperation and coordination difficult. Besides coordination problems, the lack of relational and cognitive social capital will increase the probability of inter-personal conflicts, misuse of power and free-riding in the network.

On the other hand, too strong social capital may cause other problems. During a transformation, strong inter-personal and inter-organisational relationships may cause behavioural rigidities, conservatism and lock-ins in the network because the short-term personal costs of change (loss of trust, reciprocity, friendship, etc.) can be very clear while the long-term outcomes of systemic adjustment may be quite uncertain. The insulation of a network from the outside world is another example of a situation where strong relational and cognitive social capital may lead to undesirable consequences.

In summary, the reduction of network failures seems to require a careful balancing of the three types of social capital: particularly the structural one, on the one hand, and relational and cognitive ones on the other. In terms of Woolcock, there is a need for optimising the balance between the "extra-community networks" and "intra-community ties" (Woolcock 2000).

Conclusion

This chapter has analysed the organisational dimension of the current transformation in the world economy: the growing importance of inter-firm networks in production and innovation activities. Inter-firm networks are not only motivated by traditional efficiency-considerations but also play an important role in facilitating the modern innovation processes. The chapter first reviewed the varied forms of networks discussed in the literature. The comparative organisational advantage of networks *vis-á-vis* market-based or hierarchical organisation was then analysed with four

organisational determinants: (a) similarity of resources and knowledge required by interdependent activities, (b) level of transaction costs among such activities, (c) coordination costs of interdependent activities, and the (d) nature of innovation processes. The key argument was that all four determinants influence firms' organisational decisions. Hence partial theories, which neglect some of these factors, cannot provide satisfactory explanations of economic organisation. The relative importance of each determinant depends on the particular nature of the value-adding system and its context.

The analysis suggests that inter-firm networks have become more important relative to markets and hierarchies in recent years because the growing specialisation and uncertainty of economic activities has made the network form of organisation both relatively more efficient and innovative.

Social capital plays an important role in economic organisation. It shapes the specialisation and productivity of firms, their transaction and coordination costs as well as the innovation processes. Social capital is particularly important for the success of inter-firm networks. This may partly explain why there has been increasing interest in social capital in recent years as the economic benefits of networks have become more pronounced. The other reason for the growing interest may have to do with the diminishing supply social capital in modern societies. The current transformation in working life and cultural values have led to a decay of many traditional sources of social capital.

Networks are not a panacea, however. Like all other organisational arrangements, they have their own weaknesses and problems. The chapter concluded by analysing the nature of such 'network failures'.

9 INSTITUTIONAL SETTING, INNOVATION AND SOCIAL WELFARE

The system approach emphasises the important role that institutions play in supporting innovation and learning in the business sector. There is, as Olson (1996) argues, a direct relationship between economic performance and institutions. Scholars have argued again and again that countries with the best institutions achieve most of their economic potential, while other countries are less successful.

Innovative companies may also put pressure on the institutional setting to adapt to a changing situation and to become more efficient. If, for example, pioneer companies, having initiated a far-reaching and highly uncertain restructuring and innovation process, cannot find support from the infrastructure and the organisations it houses, they may give up. *Institutional embeddedness* is particularly important for the full transformation process, which includes a fundamental change of the whole business sector.

As innovations do not automatically increase social welfare, we also have to look at possible costs related to innovation and learning. What kind of institutional changes are needed to distribute more adequately costs and benefits resulting from technical and other types of innovation? In the following, we will deal with institutional changes in Finland by referring to the labour market, the education system, the science system, and the legal system, the latter focusing on the labour law and the competition law.

University-industry relationships[72]

Science as a public good

Universities have increasingly been assigned an important role in the process of technological development. The assumption of the linear model – that firms' innovation activities depend on the creation of new scientific knowledge, and that new knowledge is step by step transformed into new products or processes – has historically created a legitimate basis for public funding of basic research in universities. In particular, the *market failure argument* developed by Arrow (1962b) and Nelson (1959), supported public involvement in basic research. The two authors convincingly argued that leaving basic research to the market would lead to sub-optimal allocation of resources, as companies systematically under-invest in basic research. In addition, only large companies could afford to invest in basic research and exploit the produced knowledge, which would give them a monopolistic position. Lundvall and Borrás recently added the argument that publicly funded basic research *provides diversity and can therefore avoid the risk of a lock-in* (Lundvall and Borrás 1997, 81).

Basic research and competitive funding mechanisms

The questioning of the linear model by the innovation system approach not oly stresses the interactive and recursive character of innovation but also puts the question of the role of universities in the process of technological development to the forefront. Two findings have particularly challenged the traditional view of the importance of university-based knowledge production. First, innovations do not always depend on new scientific knowledge; most innovations represent a new combination of existing knowledge. Second, new knowledge does not equivocally result in innovations; a direct knowledge flow from universities to firms does not necessarily exist.

These findings did not endanger the key role of universities in the process of knowledge creation and knowledge diffusion, but policy makers became increasingly concerned with the *economic benefits and the applicability of knowledge produced in universities* as well as with knowledge exchange between universities and industry. Particularly since global innovation competition has become increasingly intensive and technological change accelerated, the idea of universities having also to yield directly applicable knowledge, which can be utilised by companies to increase their innovation activities, has received increasing support.

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[72] This chapter relies heavily on the report written by Nieminen and Kaukonen (2001).

It was not until the beginning of the 1990s that the university-industry linkages gained more political prominence in Finland. When the national innovation system approach became the focal policy perspective, universities were encouraged to strengthen their relationships with industry and other users of knowledge. The information technology and biotechnology sectors can be seen as good examples of successful utilisation of scientific knowledge for commercial purposes. It is possible to argue that during the last twenty years the Finnish S&T system became institutionally more diverse and politically more integrated.

Together with the introduction of *a 'new public management'* in Finland, more emphasis is put on efficiency and effectiveness. Several mechanisms have been installed to guarantee a greater relevance and efficiency of research. Public funding is increasingly channelled through competitive funding mechanisms, user involvement – including partial funding by them – is given higher priority, universities are encouraged to enhance the exploitation of research results and often research proposals have to identify not only scientific but also practical benefits. Funding mechanisms were also designed to support inter-institutional research cooperation.

These new mechanisms, as Pavitt argues, indicate an increasing emphasis on demand-side factors in the allocation of public research funding (Pavitt 2000). This is also reflected on the development in Finland, where funding for applied research has grown faster than basic research funding. But contrary to the general trend of cutting back the financial resources for basic research in Europe, Finland has continued increasing finance for basic research. However, finance of research has been shifted significantly from core funding to public funding bodies.

The introduction of competitive funding mechanisms can be seen as a strategy to improve research quality and to introduce a more entrepreneurial orientation. It can also stimulate changes within universities, as it may give higher priority to new scientific fields and research areas. So far, universities have been slow in reorienting the current expenditure structure and to release a larger sums of money for supporting the development of new scientific fields.

Universities increasingly develop contacts with external, non-university actors and raise external funding. But the situation differs significantly among disciplines. Technical, natural, and medical research is financed by industry to a great extent, while social sciences are mostly financed by public administration. This indicates not only different interests of their financiers but also different orientations and cultures in the various disciplines. One can find, however, new initiatives in the field of social sciences, for instance, that seem to show increasing interest in the business sector – even though the relative weight of these linkages is still marginal (Nieminen and Kaukonen 2001).

It is important to mention that contrary to the general trend of cutting back the financial resources for basic research in Europe, Finland has continued increasing finance for basic research. This policy reflects the argument of the OECD (1998)

that there is a need for a high-quality science base. Finnish firms also seem to value university-based research, as they see the increase of their knowledge base as one of the most important advantages resulting from cooperation with universities (Nieminen and Kaukonen 2001). But, as in other countries as well, universities are not the dominant cooperation partners in corporate innovation processes. In general, companies cooperate more often with their clients and their supplier-firms.

However, finance of science has to some extent been shifted from core funding to public funding bodies. Together with the introduction of *a 'new public management'* in Finland, several mechanisms have been installed to guarantee the greater relevance and efficiency of research. Public funding is increasingly channelled through competitive funding mechanisms, user involvement – including partial funding – is given higher priority, universities are invited to extract more revenue from licensing their intellectual property, monetary incentives have been installed, and research proposals have to identify not only scientific but also practical benefits. These new mechanisms indicate an increasing emphasis on demand-side factors in the allocation of public funding of research (Pavitt 2000b).

The nature of the linkages between university and industry

Increasing contract research as a funding basis for university research has provoked some tension within the academic community, at least in some disciplines. In general, however, externally funded research is a taken-for-granted situation among Finnish researchers, as in most cases the university budget seems to give little room for financing basic research to a greater extent. The budget of research institutes is often overwhelmingly financed through funding based on programmes launched by the Academy of Finland, Tekes or other institutions and not from the university budget. To increase their financial bases, research units orient themselves more towards the business enterprise sector and public services by developing cooperative linkages (Nieminen and Kaukonen 2001).

Many researchers argue that contract research does not necessarily contradict academic aspirations. Nevertheless, they also mention some problems related to the often short-term contract-based research. Being under pressure in applying for new projects, continuous knowledge accumulation is more difficult to achieve. Also, being pressured to keep deadlines, it might become difficult for researchers *to fully utilise the results of their research to advance their scientific career.* Research units need to develop a strategy to balance direct basic funding and external funding.

Of course, increasing the knowledge stock as well as creating new scientific instruments and methodologies are not the only benefits resulting from publicly funded basic research. Salter and Martin (2001) mention other advantages: training

skilled graduates, forming professional networks and stimulating social interaction, increasing the capacity for scientific and technological problem solving, and creating new firms.[73] In an emerging knowledge society, universities' education function is of particular importance, as it is an effective way to diffuse knowledge. It seem that Finnish firms also value the education function of universities very highly (Nieminen and Kaukonen 2001). The importance of the different forms of economic benefits is of course not the same for all industries.

Finnish researchers seem to have few problems with the growing importance of competitive funding mechanisms. In some cases, the budget of research institutes is overwhelmingly financed through funding based on programmes launched by the Academy of Finland, Tekes or other institutions, and not from the university budget. To increase their financial bases, research units orient themselves more towards the business enterprise sector and public services by developing cooperative linkages (Nieminen and Kaukonen 2001). Interpreting these changes, scholars in science studies have come up with the idea of a *new mode of knowledge production* (Gibbons et al. 1994). While the traditional mode emphasises the disciplinary context of knowledge production, the new mode is application-oriented and entrepreneurial.[74] We can see some developments in this direction in Finland.

Concerning the diffusion aspect, the application of the innovation system approach has lead to a repositioning of universities in the idea-innovation chain. While the traditional linear model assumes a hierarchical relationship between university and industry, as firms depend on new scientific knowledge, the interactive model is based on the assumption that networks are the most effective coordination forms for allowing intensive and continuous knowledge flows in different directions. Therefore, universities are increasingly seen as *an integrated part of innovation systems*. And they start strengthening their diffusion power by establishing specific units.

Networking between universities and industry

The traditional transfer perspective, which assumed the utility of scientific knowledge for industrial innovations, needs to be replaced by the idea of joint knowledge creation and knowledge sharing between science and industry (OECD 2000b, 162). A major advantage of such a strategic partnership is that firms can *improve the exploitation of their internal knowledge by using complementary sources of knowledge*. In turn, advanced users will typically force the academic world to increase their efforts (Lundvall and Borrás 1997). Consequently, knowledge generation and knowledge diffusion become mutually interdependent (OECD 1998b).

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[73] We should add here that our research interest in innovation systems does not take into account other non-economic functions of universities, such as the cultural function, for example.

[74] This Mode 2 argument has received a lot of criticism. See e.g. Pavitt (2000) and Ziman (1996).

Together with the fact that money is increasingly channelled through governmental funding bodies, Tekes and the Academy of Finland in particular, networking universities, industrial R&D laboratories, and governmental research institutes has become a major aim. Finnish policy makers see the industry-science relations as a crucial edge in global competition. Tekes, for example, understands itself as a bridging institution between science and industry. In addition, the Finnish cluster programmes are a new example of a public policy aiming at stimulating and supporting multilateral research cooperation (Prihti et al. 2000).

University researchers seem to understand research networks primarily as a resource. The financial benefits drawn from cooperation are significant. Knowledge-related benefits, however, may be even more important; particularly *access to 'know-how' and 'know-who'* is often mentioned. While in general, cooperation is seen as functioning smoothly, *intellectual property rights* seem to form an exception. Namely, for some universities, commercialising research result is a new issue, and they lack the knowledge of how to do it. Neither is university-level innovation policy always clear despite recent attempts to formulate definite policies.

Despite the fact that innovative companies in Finland, more than in other European countries, cooperate with universities, there are still many companies, particularly SMEs, which are not aware of the potential benefits of such a cooperation. Non-cooperating companies see the lack of information as a key factor that hinders establishing linkages to universities. But is is also very difficult for SMEs to develop the needed absorptive capacity. A possible measure could be to enable SMEs to hire their first academic employee. Companies cooperating with universities are, naturally, better informed about university research, training, and other activities than non-cooperating ones. It seems to be obvious that *universities need to be more proactive* also regarding knowledge users that are not involved in R&D activities. Building up networks is, however, a long-term process that requires active development of mutual interests, and trust from both parties.

The role of social sciences

From the innovation system perspective, the fact that *social sciences, including business schools, are less engaged in cooperation with companies* (Nieminen and Kaukonen 2001) may be seen as a problem. As has been stressed elsewhere, technological and social changes are closely intertwined. Indeed, knowledge embedded in organisational forms, management practices, and social institutions is often mentioned as an important factor in achieving sustainable competitiveness.

The effective functioning of the innovation system may, therefore, increasingly depend on organisational and social innovations resulting from research in social sciences. Also, researchers in social sciences can gain significantly from cooperating with companies. Business practices may represent advanced organisational and

regulatory solutions and induce a knowledge impact on social sciences as well. Therefore, both sides, industry and social sciences, can benefit from intensive cooperation. In addition, social sciences could particularly contribute to a better understanding of the *role of the innovation system in the economy and society* and the interconnections between the innovation system and other economic and social subsystems.

The limited social science engagement in cooperation with industry may partly be explained by the fact that Finnish policy makers emphasise the technical character of innovation systems. Of course, scholars in social sciences themselves seem to have some reservations about engaging in cooperation with industry, and industry is not primarily interested in social scientific knowledge either. There is, contrary to the situation in the other Nordic countries, no long-term tradition in Finnish social sciences *to take up technical and economic issues as research fields*. And many social sciences research institutes at Finnish universities do not have the critical mass to develop long-term research perspectives in this area.

There is great potential in social sciences to contribute to research on innovation problems. Nowadays social sciences have become the most rapidly growing discipline in Finland. In addition, the Academy of Finland has started to set up research programmes, such as those on intellectual property rights and on the research environment that are dealing with the core problems in innovation systems. To further support interdisciplinary research in the field of innovation systems, it becomes important to direct research in social sciences to this field.

Problems in university-industry cooperation

Compared to other OECD countries, cooperation between universities and industry is, as the CIS data indicate, quite intensive in Finland (Foyn 2000).[75] However, it takes place mostly within the frameworks of collaborative contract research and public research programmes, while university-industry relationships seldom include the establishment of 'hybrid research groups'. This demands intensive informal knowledge exchange; personal relations are valuable social capital for researchers in the development of research programmes.

Due to the growing importance of collaborative research, knowledge exchange has become increasingly bidirectional, while contractual research is primarily a uni-directional knowledge transfer from universities to industries. The observation "that industrial researchers have become members of informal networks wherein academics as well as industrial researchers discuss their research projects and findings" (Meyer-Kramer and Schmoch 1998, 841), also seems to characterise the Finnish research landscape. We can speak of an increasing importance of the 'interactive research mode', in which knowledge flows in several directions within

[75] It is important to mention that there are significant differences among disciplines in the way in which they are oriented towards basic research, applied research or development and in the way in which they cooperate with industry.

innovation networks (Nieminen and Kaukonen 2001). But the interactive research mode depends on the development of trust-based relationships among the network members.

Meyer-Kramer and Schmoch also mention some cooperation problems. Industrial R&D laboratories are more accustomed to interdisciplinary research activities since they deal with technological problems, the solving of which often needs integrated knowledge from different disciplines. Therefore, interdisciplinary research teams are much more common in industry than in universities. University research teams, on the other hand, in most cases consist of scientists from one discipline, dealing often with narrow, abstract problems. To form interdisciplinary research teams seems to be a problem in Finnish universities. It is quite obvious that these differences make cooperation in 'hybrid groups' rather difficult.

Meyer-Kramer concludes that to set up *interdisciplinary approaches in academic institutes* becomes crucially important for further stimulation of university-industry cooperation (1997, 308). In Finland, some attempts have been made to foster interdisciplinary research within universities. But as interdisciplinarity becomes increasingly important, universities need to foster the development of new organisation forms to tear down disciplinary boundaries, or at least to make them more permeable.

Trend towards internationalisation of research cooperation

There is also a trend towards internationalising the benefits of basic research. Fierce global competition, as Pavitt (2000a) argues, forces *companies to search for the most advanced university institutes worldwide.* The most successful companies have learnt to engage in global innovation networks and to make use of foreign basic research. Finnish universities seem to be well networked not only on the national but also on the international level. They participate quite extensively in European research programmes.

As a major part of the knowledge needed in Finland is produced abroad, universities have taken up the *role of knowledge transfer institutions.* The fact that Finnish government funding bodies stress the importance of international cooperation indicates that they have assigned such a role to universities. Encouraging universities to engage in cooperation with foreign universities and firms and to link the local economy through them to global networks seems to be a promising strategy to gain from the trend towards internationalising the benefits of basic research (Lundvall and Borrás 1997, 85).

Organisational problems

As has been mentioned earlier, universities have a variety of different functions. The international discussion on universities, however, seems to focus only on

respective specific functions. More concrete, the discussion either refers to higher education or to a research function. But to realistically evaluate the current state of universities and their efficiency, one has to assume a more comprehensive picture. Matching their resources with the various tasks and related expections becomes a major challenge for universities also in Finland.

To maintain internal synergies, it is important to discuss and define principles and priorities in developing the whole spectrum of functions that universities are expected to serve. Otherwise there is the risk that universities become some kind of 'umbrella' hosting a variety of different units with different focal points and increasingly diverse activities hardly linked to each other. There seems to be some evidence that Finnish universities have developed a more pragmatic attitude that makes it increasingly difficult to identify the overall role of universities in economy and society (Nieminen and Kaukonen 2001).

Such a pragmatic view also raises some questions with respect to the internal structures and management principles within universities. The expansion of university research and its finance from new resources has brough about increasingly differentiated internal structures. There is a need not only to reflect on the core activities of universities and how to integrate them but also on new organisation models that, while allowing diversity, should nevertheless be able to maintain internal synergies.

Vocational education in Finland: the polytechnics[76]

Combining theoretical and practical knowledge

The establishment of the polytechnics has been characterised as the biggest reform of the education system in Finland. It follows the European trend of expanding and improving education and particularly vocational education, demanded by a trend towards abstractification and increasing knowledge-intensity of work. The reform also reflects the high esteem for formal education in this country. Before the reform, vocational training was less attractive, since it was limited to the upper secondary level. The establishment of polytechnics not only improved the quality of vocational training but it also made it more prestigious, as it was put on one and the same level with general education. In addition, graduates from polytechnics have a much broader knowledge base than those coming from vocational education schools, which makes horizontal and vertical mobility much

[76] This chapter draws heavily on the report written by Raivola et al. (2001).

easier. The polytechnic reform also helped higher education to break free from its isolation from working life.

It is the main aim of the newly established polytechnic system to educate a new type of expert who corresponds with the skill demands of the emerging knowledge economy. This means, in particular, that graduates from the polytechnics should have *a strong practical orientation.* Skill formation in polytechnics can therefore become an important element in improving companies' innovation capability. While universities' teaching activities focus more on teaching 'know-what' and 'know-why', polytechnics should concentrate more on 'know-how' in the process of teaching and skill formation, enabling their scholars to deal with problems in working life and to introduce and cope with change.

It is misleading, however, to characterise 'know-how' as practical rather than theoretical (OECD 2000e, 15). There is no doubt that solving problems in working life requires a lot of practical experience in the field. However, problem-solving also depends on self-reflexivity, implying the capability to monitor the environment, critically dissociating oneself from the traditional functioning of reality, and the development of alternative ways of acting. Such kind of self-reflexive problem solving is not possible on the basis of practical knowledge only; it also depends on theoretical knowledge. 'Know-how', therefore, *combines both practical and theoretical knowledge.*

The polytechnic reform aims at integrating the two knowledge elements and finding pedagogical solutions for this problem. Particularly project work and the final thesis can be seen as tools aiming at combining practical and theoretical knowledge. While the idea of integrating practical and theoretical knowledge through learning processes is widely accepted, there seems to be some uncertainty among both teachers as well as the students about how this can be done.

Cooperation involving polytechnics and universities

Universities and polytechnics represent the two pillars of the higher education system in Finland. While both institutions have different functions in the education system, they are expected to intensively cooperate in various areas such as the teacher education, the teaching of students, and research. So far, cooperation between the two higher education institutions seems to be rather limited. To some extent universities and polytechnics cooperate in developing joint teaching programmes. However, there seems to be little cooperation, as far as R&D activities are concerned.

The fact that most polytechnics have not developed their research capacity yet can be seen as a major factor that hinders research cooperation between the two higher education institutions. There are of course a few polytechnics engaging very actively in research activities, but the majority is lacking the needed infrastructure as well as the human resources. In some cases, universities retain from cooperation, seeing polytechnics as competitors in research activities. And

the fact that polytechnics focus on the knowledge-based development of work and applied research, while universities, although they are moving more towards applied research, focus on basic research may explain the weak research cooperation between the two institutes. Also, the fear that students from polytechnics will continue studying in universities may be seen as a factor that hinders universities from cooperating more extensively with polytechnics.

The fact that boundaries between the two institutions of higher education are not clearly drawn can be seen as major factor that hinders cooperation. It might be useful to sharpen the role of the two institutes in research and to point out clearer rules for cooperation. One could define the role of polytechnics more as a *knowledge dissemination institution*, while universities focus on the creation of new scientific knowledge. But in order to be able to take up this role, polytechnics have to have *absorptive and transformative capacity*, a stock of pre-existing knowledge necessary for the assimilation of new knowledge. This means that polytechnics have to engage in research as well and to be able to cooperate closely with universities. Of course, no clear boundaries can be drawn as in some fields, for example, knowledge creation and knowledge diffusion merge into one process. In addition, while some universities are disseminating their knowledge very actively, some polytechnics might engage more directly in scientific research. Nevertheless, having closer contacts to regional businesses, polytechnics are well suited to take up this *intermediary role in the process of knowledge creation and knowledge diffusion*.

The reform also opens up possibilities to *restructure educational research* bringing members from universities and polytechnics into a much tighter partnership, in which they engage in sustained dialogue to design, implement, and evaluate R&D projects. Such collaborative research could particularly focus on methods, strategies, and tools for dealing with the main problem with which teachers from polytechnics are confronted: to enable students to solve problems in working life in a self-reflexive way by integrating practical and theoretical knowledge. Both sides could benefit from such research. While teachers in polytechnics could improve their curricula, researchers from universities could use the new knowledge to rearrange teacher education.

Both partners would have the opportunity to contribute to the integration and combination of different kinds of knowledge, which could support knowledge creation in both institutions. Members of polytechnics could improve their research skills, enabling them to research their own institution more intensively. At the university, such research cooperation would not replace but actually complement and enrich basic research. Although different orientations and cognitive frames may makes such cooperation difficult to achieve, the potential pay-off for the improvement of the vocational education system can be significant (OECD 2000e, 82). It is, therefore, very important to encourage more joint research projects.

A trend towards academic drift?

The Finnish higher education system is based on the principle of duality. In this system, the polytechnics have been given a specific role: to raise the standard of education with respect to working life. So far, polytechnics often seem to have difficulties in defining their particular role in the higher education system and to develop a concrete profile. There are, as Raivola et al. (2001, 104) argue, some signs indicating a trend towards academic drift as it has happened in the UK.

The changing qualification structure associated with the rapid growth of the polytechnics, on the one hand, and the shrinking of the upper secondary vocational education on the other, may also cause some structural problems. According to OECD studies, in many industries the labour force educated at *upper secondary vocational level* contributes significantly to value added. Of course, also in these industries a solid theoretical basis is often indispensable. (Raivola et al. 2001.) In this respect, we can also mention the German apprenticeship system.

Since the greater part of the work is carried out in so-called *low-tech industries* in Finland, the need for scholars coming from the secondary level of vocational education is still great. This also applies to major parts of the service sector. Still it seems reasonable to argue that in Finland there is a need to develop and improve upper secondary vocational education as an alternative route into working life. Due to the fact that most institutes of the upper secondary level of vocational education have been transformed into polytechnics, the secondary level of vocational education now seems to have a negative image among students. The aim to increase the number of apprenticeships is a concrete step in this direction. In general, there is a need to improve the profile and image of the secondary level of vocational education. In Germany, for example, companies esteem apprenticeship very high, although some changes are being discussed. It is also very important to reduce the dropout rate on the secondary vocational education level, as this contributes significantly to the high youth unemployment rate in Finland. The secondary level of education must become the basic qualification for all students in vocational education.

The role of polytechnics in the regional economy

Geographical proximity is an important factor in the knowledge creation process, as it promotes repeated interactions as an important basis for the development of mutual trust relationships (Saxenian 1994). As the network of polytechnics in Finland covers the whole country, preconditions for polytechnics to develop trust relationships with industry and to take up a regional development function are rather good. One can, however, have some doubts about whether such an *extensive regionalisation* of higher vocational education is an effective way to organise the polytechnic network.

A major problem is that in many cases, polytechnics offer more or less the same kind of general training programmes. As they are often very small units, they do not have additional capacity to focus more on specialised courses that are adapted to the specific needs of the regional economy. Moreover, rapidly outdated knowledge makes it necessary to continuously update the course material. On the other hand, for developing new specialised training courses, the region might not be the adequate point of reference. There is a need to continue structural development of the polytechnic network. As learning and knowledge creation in general take place in single regions overlapping firm networks, in which companies with complementary knowledge and competencies cooperate, it may become increasingly necessary for polytechnics to get involved in *trans-regional cooperation*. Extensive trans-regional network formation among Finnish companies also increases the demand for *intensifying cooperation among polytechnics*.

Intra- and inter-organisational aspects

While in companies problems of knowledge management are increasingly addressed, this seems to be less the case in educational institutions, as here the single teacher and not the community of teachers is mostly seen as the carrier of knowledge. Therefore, transforming teaching in polytechnics into a network profession may prove to be an important means of improving the management of knowledge (OECD 2000e, 74).

Intra-organisation networking is particularly important, as one of the main aims of the introduction of polytechnics was to establish new working-life-oriented study programmes, benefiting from multi-disciplinarity. It seems that until now many teachers working in Finnish polytechnics have not interpreted their institution as a *network of interactions* (Tsoukas 1992), although in many cases multi-disciplinary study programmes have already been established. Exchange of knowledge, however, can become difficult, as teachers at polytechnics are usually specialists with different knowledge bases, professional languages, and different content in much of their tacit knowledge. To reconstruct *the institutional culture* in such a way that combining differences results in the development of new knowledge seems to be necessary though it is also rather difficult.

Knowledge management is not restricted to developing intra-organisational structures that support internal knowledge flows only; the development of external networks with other polytechnics and universities as well as with regional businesses and other economic and political actors is equally important. Particularly cooperation with the regional T&E (Employment and Economic Development) centres could be very useful. In this cooperation, the regional T&E centres could take up a diagnostic role, identifying various problems in the business sector, while polytechnics could take up a curing role, providing solutions for the identified problems. However, particularly for small units, to become a key player in regional innovation systems is an aim difficult to achieve.

Implications of rapidly outdated knowledge

The reform of the vocational training system in Finland was a reaction to the need for improving skills and competencies related to working life by establishing polytechnics. Another phenomenon of the knowledge-based society is, however, that knowledge becomes more and more rapidly outdated. This aspect seems to be less reflected in the reform, as it is based on a *sequential model of education*.

In practice, this means that more than half of an age group in Finland is *studying up to the age of 25*. In general, they study full-time, leaving practically no time to acquire any kind of work experience. This means that due to the application of the sequential model, the great majority of students enter polytechnics directly after finishing the upper secondary education. Taking the problem of rapidly outdated knowledge seriously implies the need to develop more *integrated concepts of learning and working*, in which phases of working and learning alternate, and in which the basic idea of *lifelong learning* is realised. A more comprehensive view seems to be necessary in combining initial with further education in a more coherent way.

Regulation and innovation: the competition law[77]

Almost all regulations affecting output, profitability, and technological constraints also have, as Metcalfe (1995) argues, implications for innovation activities in one way or another. This argument, however, has hardly had any impact on the research agenda of the innovation system approach. Little attention has been given to the question in what way and to what extent regulatory standards influence innovation processes. On the other hand, *dynamic efficiency* has only seldom been adopted in the law; in economics and law, approaches developed to analyse rule formulation are based on *static efficiency.* This may lead to different innovation failures: regulations may hinder innovation processes, they may stimulate too many innovations, and they may direct resources in a socially not desired direction (Määttä 2001). In the following, we will discuss the aspect of dynamic efficiency by referring to the competition law.

Social welfare: low prices or innovative products?

The competition law has traditionally focused on *prices charged and excess returns* as indicators of social welfare. The main assumption was that consumers would

[77] This chapter relies heavily on the report written by Määttä (2001).

benefit from competition through low prices. This argument, however, is hardly sustainable, as patterns of demand, due to increasing individualism, have changed significantly. While in times of traditional mass-demand, social welfare was associated with low prices in the first place, we can nowadays talk about *diversified quality demand* (Streeck 1991). This means that social welfare can no longer be linked with low prices; it also implies quality improvement, diversification, and innovation.

At least in the view of many consumers, social welfare is more associated with *quality and novelty* than with low prices. As Nelson and Winter (1982) argue, we will probably gain more from continuing innovation than from competitive prices. In addition, productivity in high-tech industries is mainly based on innovation and not on cost cutting, which means that competition policy can be less strict. Last but not least, innovation may actually also insure competitive prices for consumers. The use of new materials, for example, can reduce costs. This means that causality between competition and innovation goes both ways, while competition may effect innovation, the latter can also increase competition. These various factors may explain why some scholars assume that competition policy in the future will be shaped more by concerns about innovation and competitiveness than in other periods in recent history (Jorde & Teece 1992).

Mainstream competition analysis, however, is static and neglects innovation (Määttä 2001), while the dynamic aspect of continuous economic renewal as dominant characteristic of the new economy is neglected. The basic argument is that competition is good as it gives consumers the greatest choice at the lowest possible price. Monopolies and cartels, in contrast, often lead to socially inefficient allocation of resources, shift to producers wealth that would otherwise remain in the hands of consumers, and generally waste resources through inefficient production and insufficient innovation (Wood 1997). This argument, however, is very one-sided; it does not conceptualise innovation processes adequately.

Schumpeterian and Arrowian approaches

A critical question then is whether the competition law becomes a *hindering factor* for innovation processes. Does the control of market power, the basic aim of competition law, curtail innovation processes? Economic theory is undecided about the question of whether competition promotes innovation activities or whether business firms with monopoly power create a better basis for promoting innovativeness (Määttä 2001). According to Schumpeter (1942), large companies are more likely to produce innovations. He gives two reasons for his argument. First, large companies have the financial resources to conduct large research projects from their own profits, and second, they can more easily appropriate the returns from their innovations since there are few competitors. Galbraith (1967) has taken up the argument maintaining that *large companies are the dominant players* in

the development and implementation of new technologies.[78] Controlling market power through the competition law, therefore, could actually reduce innovation activities within the economy.

Challenging Schumpeter, Arrow (1962b) argues that a *monopolist or oligopolists* controlling the market have *no incentive to innovate*. Therefore, the absence of competition will reduce innovation activities. By eliminating monopoly and collusion, competition policy can support dynamic efficiency.

Both positions seem to be too simplified and can be criticised on many grounds.[79] The major argument here is that neither position deals with the *problem of cooperation* within innovation properly. They both underestimate the importance of cooperation and networking within innovation processes. Schumpeter's argument legitimates the existence of R&D labs within large companies, they are actually seen as the motor of innovation activities. Their efficiency, however, is often questioned. They are criticised for being too bureaucratic and not flexible enough to immediately take in new knowledge developed elsewhere. Besides, they might not cover the whole knowledge area, which nowadays is necessary in order to develop new innovations by integrating knowledge from various disciplines. Even large firms do not have adequate resources to undertake unilateral development of some new technologies. This might become a particular problem, as companies increasingly specialise and concentrate on core competencies. There is some evidence that concentration may be less efficient in stimulating innovation activities and that joint development involving several firms becomes necessary

Arrow, on the other hand, ignores the importance of complementary knowledge in innovation processes. Too much competition may result in a *cooperation failure*. Competition may require some cooperation in order to obtain efficiency (Telser 1985). Cooperation failures are, by definition, failures to cooperate even though it would be beneficial to the parties in question and also from the standpoint of social welfare. Empirical studies have confirmed that collaborating firms are more innovative than non-collaborative ones (Smith et al. 1996). We have to add here that only if cooperation develops into trust-based networks can we expect major contributions by all partners to the collective innovation process - a process, which needs a longer time perspective.

Networks and dynamic efficiency

The fact that companies increasingly form inter-firm alliances to enable and speed up innovation processes has changed the attitude towards inter-firm cooperation. It is now widely accepted that innovation is to a great extent a cooperative process and that companies rarely innovate in isolation. One argument to support

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[78] Here we will not discuss the various attempts to empirically test the connection between competition and innovation. See e.g. Kamin and Schwartz (1982).

[79] With respect to other aspects, see Määttä (2001, 71-74).

inter-firm cooperation in innovation processes is that this may be one way to compensate for under-investment in R&D, a phenomenon that some scholars are afraid of, as knowledge becomes more codified, and therefore, more easy to acquire. This argument, however, underestimates the problem of making use of external knowledge; simple freeriding is not possible, as companies have developed a lot of in-house knowledge to be able to make use of external knowledge.

A more convincing argument is that cooperation is important in producing *sticky knowledge*[80], which becomes a crucially important asset in global competition. Sticky knowledge may give cooperating companies a leading position in their market; it may trigger 'increasing returns'. With *increasing returns*, the market at least for some time tilts in favour of the provider that gets out in front (Teece and Coleman 1998). While the phenomenon of increasing returns may result in the elimination of some competitors, dominant positions in a knowledge economy in general do not last very long; dominance is likely to be temporary, particularly in a very dynamic context.

The current situation is characterised by an extreme acceleration of innovation processes, in which it is often difficult to separate competitors from collaborators. Dissolving and re-establishing cooperative relationships is a continuous process, so that the *definition of competitor and collaborator* becomes fluid. In such a situation, as Lundvall and Borrás (1997) argue, transforming competitors into cooperators within innovation networks is an important aspect of competition policy.[81] Setting up innovation networks can be necessary to strengthen national competitiveness. Social benefits related to the establishment of strong cooperation in innovation processes may be higher than the arm-length's mode in promoting innovation.

A competition policy that further speeds up innovation by allowing innovation cooperation, on the other hand, may result in some *major social problems*. The very speed of change can be seen as a key factor that contributes to increasing labour market and social exclusion problems. This argument is, for example, expressed in the concept of 'skill-biased economic transformation'. Slowing down the rate of change, however, is hardly possible in global markets. Lundvall and Borrás plead for a different solution. To increase the innovation potential and to improve absorptive capacity, they argue, is a more realistic alternative. The focus should be on the problems created by accelerating change and on redirecting the forces of change towards the solution of these problems (1997, 144). This of course means that competition policy needs to be co-ordinated with other policy areas such as labour market or regional policy, for example.

How to reform the competition law?

What has been said so far seems to support the argument that a reform of competition law is needed. This seems to be true for Finland as well, as the concept of static efficiency is still dominating in lawmaking, although some changes

[80] See Chapter Four.

[81] See Chapter Ten.

have already taken place. Particularly in high-tech industries with the emphasis on investment in R&D, we may gain more from cooperation than from competition. They may provide a socially beneficial ground for cooperation among potential competitors. "Such cooperation is likely to prove pro-competitive, since it can increase returns to innovation through improved appropriability, encourage dissemination of innovations, facilitate exploitation of economies of scale and scope in the creation of new knowledge, and permit better spreading of the risks associated with the investments in R&D, when market mechanisms for risks sharing perform inadequately" (Määttä 2001, 98—99). Furthermore, new technologies often require cooperation, as is the case with biotechnology.

Does this suggest installing different standards for different industries? In general, the *principle of generality* should be applied, meaning that general principles should be formulated which can be applied indiscriminately to all sectors, although this may cause some problems, as far as handling issues relating to industrial dynamism is concerned. Detailed formulations should be avoided, especially in circumstances in which technological change is rapid; categorical and schematic rules may be dangerous, as they are likely to hinder technological change. In addition to this *principle of flexibility,* the *neutrality principle* should be applied. This implies that neither choices between innovation strategies nor choices between organisation forms in which innovations are planned and implemented should be influenced by legislation (Määttä 2001, 177ff).

The labour market[82]

In the course of development towards a knowledge-based economy, the labour market is undergoing significant changes. It is quite obvious that the traditional idea of a lifelong, highly standardised employment, typical of a stable economy in the past, is being increasingly challenged. Due to this development, we can no longer assume that the normality of having a high level of stability in the course of one's life will continue. What we are witnessing is an *escape from the logic of normality*.

Together with these changes, the *traditional welfare state*, which was aimed at achieving equality mainly by providing a proper education at the beginning of the work career to all citizens, is also being put on the test. Further state intervention has not been seen as necessary, with the exception of financial support in case of cyclical unemployment. Collective steering, however, might no longer be possible, as a high degree of stability in the life course of workers together with standard lifelong employment are increasingly challenged. It might be necessary to develop

[82] This section draws heavily on the report written by Suikkanen et al. (2001).

together with increasing diversity of work careers and life courses a *new concept of social policy*.

In Finland, the recession at the beginning of the 1990s triggered major economic changes as the pace of development towards the knowledge society increased. The crisis caused a huge drop in employment. A significant number of routine low-skilled jobs have been eliminated, while at the same time, fewer high-skilled jobs requiring managerial competencies and specific expertise have been created. Only at the end of the decade did the entry rate into normal employment surpass the exit rate. Consequently, unemployment rose dramatically during the 1990s with its peak in 1994. As late as the year 1998, more than half a million (21.7%) 21- to 64-year-old people belonging to the labour force were unemployed for a shorter or longer period of time. The number of people unemployed annually has not returned to its pre-depression level, although economic indicators show that Finland has clearly recovered from the recession of the early 1990s.[83]

It stands to reason that the reduction in jobs in the 1990s hit hardest the people with little or no higher education, mainly elderly people but also school-leavers with little vocational training. While the share of people without any diploma has decreased in the workforce, the employment of highly educated people has increased after the recession. This change has actively been supported by education policy aiming at transforming Finland into a *'high-road' country* with a highly skilled workforce.

The *structuration of unemployment* is indicated by the fact that highly educated young people are much more likely to re-enter the labour market than elderly people with low education levels. *Inclusion* is mainly restricted to high-skilled employees, while *exclusion* is a phenomenon, which primarily affects low-skilled people. In a dynamic labour market with an increasing demand for highly educated people, poorly educated people of working age face the problem of becoming long-term unemployed. As the skill gap widens, there is a risk that these people become socially excluded and unemployable.

Increasing instability of work careers

The *structuration of unemployment* indicated by increasing long-term unemployment is a new phenomenon of the Finnish labour market (OECD 2000f). *Increasing instability in work careers* is another one. Both transition from unemployment to the employed labour force and transition from employment to unemployment have increased. It is quite obvious that during the 1990s transition from work to unemployment and back to work has become a more common phenomenon. This means that increasingly fewer employees have an uninterrupted, stable work career.

The fact that moving from employment to unemployment and back to

[83] The degree of annual unemployment differs from the official rate of unemployment, which is based on cross-sectional data.

employment has become more common indicates the increasing instability of work careers. The fact that growing employment in Finland during the late 1990s did not result in more permanent jobs indicates that *destabilisation of employment is not* a phenomenon of the depression years, but is of a more permanent character. In a very dynamic labour market, in which knowledge is becoming outdated in increasingly shorter periods, people cannot keep their position or even stay employed without continuously improving their existing knowledge. Therefore, we can identify a new phenomenon: work careers increasingly combine phases of employment with those of unemployment and temporal periods of training.

Growing dynamics of the labour market as an opportunity

So far, the *growing dynamics of the labour market* is associated mainly with the risk that people with outdated knowledge, skills, and competencies are likely to become unemployed. This means that there is continuous pressure to renew skills and competencies through further training. However, the fact that the transformation towards a knowledge economy produces *new skilled jobs* can also be interpreted as offering new and better job opportunities for people. Highly skilled employees can search for new jobs that match better with their skills and competencies. At the same time, participating in further education can open up new job opportunities and may contribute to the improvement of their position in the labour market. There seems to be some indication that people more and more often leave their jobs voluntarily to improve their labour market status.

In Finland, *active planning of one's own work career* has obviously become more common. While changing occupations and business fields were earlier a relatively rare event, it is now often the case that younger employees change jobs several times during the earlier part of their work career. Also, the fact that more and more employees have at least a second diploma indicates that they have become active planners of their work careers. It is obvious that such changes are not the result of a weakening economic position on the labour market; on the contrary, a period of rapid economic growth seems to increase, for example, the probability of being active on the labour market. In the younger age groups, the repeated changing of business fields is normal and the rule — a factor, which is a feature of both the dynamic labour market and individual adaptation.

Labour market data indicate that an increasing number of people are prepared to become more active in order to improve their position in the labour market. This is rational behaviour in an economy in which employment risks for those staying put increase, while at the same time, the dynamic market opens up new and better jobs for highly skilled employees. At the same time, due to social differentiation, individualisation and a plurality of lifestyles, there is also a growing demand for individual work careers from employees' side. The development of *social diversity* representing the end of traditional homogeneity in work careers is clearly visible in people's life courses. This diversity seems to become more accepted

in the Finnish society as well.

It is important to mention that *individualised labour market strategies*, including continuous self-development and learning, not only improve employees' positions in working life, but that they are also a mechanism to support and accelerate the current transformation process. The more employees care about the adequate use of their skills and competencies and about the further developmentof these competencies, the easier it will be to fill the growing number of jobs requiring higher skills, while jobs requiring low skills can be made redundant. Companies will have at their disposal the needed knowledge to hold their own in innovation competition. To increase employees' vertical mobility by providing further training is, therefore, also in their interest.

Individuals' opportunities to shape their own work careers are often limited by rigid regulations. Current social policy is justified on the basis of the individual being treated equally. As work and life courses are characterised by growing diversity, it is becoming increasingly important to support *individualising work trajectories*. There is a need to renew the system of work and social security towards individual welfare agreements.

A new perspective on labour market policy

In the knowledge economy, where adaptation to change becomes part of normal working life, the creation of preconditions for *proactive training and competence development* needs to be given high priority. This is necessary to enable employees to organise and regulate their work in a competent way, to adapt to new technological challenges, and to develop more active career planning. As workers take on more responsibility, their competencies need to be strengthened through lifelong learning. They need to be able to participate in further training while being employed. In addition, employees need to have the right to change employment without losing any benefits.

To deal with the problem of unstable work careers, Schmid (1996) suggests developing so-called *transitional labour markets.* They can be understood as bridges between paid employment and other forms of employment and productive activities. They guarantee the right to change between various types of employment and other productive activities, including further training. And they compensate for financial losses related to processes of change by offering transfer payments. Transitional labour markets, we can conclude, represent institutions that *support variability within stable work careers*.

There is the risk, however, of slow learners becoming socially excluded. Slow learners, among them the unskilled, the handicapped and the elderly, will have difficulties in preparing themselves all the time for new tasks and problems; continuous learning may be beyond their capacity. Being under pressure to innovate continuously, companies may select only rapid learners, while they may dismiss

slow ones (Lundvall and Nielson 1999). For them re-entering the labour market becomes increasingly difficult, particularly in a situation of shrinking low-skilled jobs. It is important to keep these people employable but *specific measures* have to be taken to reintegrate them into the labour market and to open up employment opportunities for them. Education with a new professional diploma might be one way to solve the problem of reintegration, but it might not always be a workable solution. In some cases, it will be necessary to offer people *sheltered employment* for a longer period of time.

According to Schmid (1996), we are faced with a *paradigm shift in labour market policy*, with the state assuming a new role in labour market. The traditional Leitbild of a *'caring welfare state'* will be replaced by that of a *'cooperative social state'*. The cooperative social state concentrates on providing resources to strengthen the competencies of self-organising individuals. It encourages workers to continuously improve their skills and competencies in order to increase their labour market chances and to ameliorate their employment situation. And it provides the educational infrastructure necessary for pro-active qualification processes and competence development.

Flexible work and the labour law[84]

The concept of flexibility

Continuous organisational restructuring also puts the spotlight on work and employment as well as employment relations and work arrangements, as techno-organisational renewal will lead to a fundamental transformation of work. *Flexibilisation of work* is one of the key topics, which characterise the transformation process. The traditional form of work, based on full-time employment, a career pattern over the life cycle, clear-cut occupational assignments, standardised working hours and collectively agreed wages, is shrinking continuously.[85]

Flexibilisation of work has several dimensions (see also Castells 2000, 105):

- *working time:* deviations from the standard full-time job are no longer exceptional cases;
- *work tasks:* work is no longer limited to a specific number of predefined tasks, instead, work is increasingly very generally prescribed, allowing a very broad deployment;
- *wages:* wages are becoming more flexible and for specific groups of workers they can fall short of the standard wages agreed in collective bargaining;
- *location:* workers do not have a fixed workplace, in project work, for example,

[84] This chapter is relies heavily on the report written by Koskinen and Mikkola (2001).

[85] Nonetheless, the majority of workers are full-time employed in an open-ended employment contract.

they increasingly change workplaces. Others work at least part of their working time outside their workplace, from home, or in the location of a different company;
- *job stability:* work is increasingly organised in projects, which does not include a commitment of further employment; and
- *social relationships between the employer and the employee:* while these relationships were traditionally based on well defined rights, trust increasingly becomes a key basis of modern employment relationships.

In the flexibility discourse, different forms of labour flexibility and adjustment in the workplace have been loosely grouped into two extremes – *'functional' and 'numerical' flexibility* (OECD 1998a). Functional flexibility concerns employers' authority to vary the allocation of work within organisation so that changes in jobs can easily be made when required. Numerical flexibility, on the other hand, takes the form of varying the size of the workforce in response to changing requirements, whether these involve seasonal fluctuations, responses to changes in customer demand, or market changes. These forms of flexibility may involve the introduction of temporary working, part-time work, working from home, working on-call, or casual labour.

Flexible work raises the question of *security*, as an inevitable feature of a 'flexible work' arrangement is that it is inherently insecure (Brown 1995). As the trend towards flexible work continues decreasing of standard work patterns seems to be irreversible, the question then is how we can achieve flexibilisation of work without increasing workers' insecurity in the labour market? What kind of legal regulations do we need to *combine work flexibility and social security*? The trend towards flexibilisation of work is not only enabled by techno-organisational restructuring, but also supported by an *increasing individualistic orientation* among people. We will discuss the above issues by referring to the Finnish labour law[86].

Some aspects of flexible work

In general, the Finnish labour law does not hinder neither functional nor numerical flexibility.[87] Social security is particularly at stake when we refer to *numerical flexibility*. The trend here is to normalise atypical employment for both part-time work and fixed work. The general rules regulating work also apply to flexi-workers, which makes the discrimination against flexi-worker less likely. In addition, a fixed-term work contract cannot be made without justifiable reasons. From the perspective of workers, normalisation of atypical work contracts increases security.

[86] This also includes the new Employment Contracts Act, which is due to come into effect shortly.

[87] However, some requirements have been stated limiting the ability to arrange work freely.

Functional flexibilisation creates fewer problems concerning social security.

But some other aspects are worth discussing. Functional flexibility often implies decentralisation of decision-making power and responsibility; the whole management of the work process is given to a working group. The fact that the execution of management functions and supervision of work, formerly entitled to the employer, becomes part of the work role of an increasing number of employees causes problems in differentiating between various groups of workers and even in distinguishing between management and workers. This is not reflected in the labour law so far.

Knowledge work is more and more performed in work groups. Therefore, it becomes difficult to attribute particular work results to a single person. In fact, solutions for specific problems are often the results of long discussions, in which no single 'inventor' can be identified. *The collaborative nature of work* raises the question of whether the individual work contract should be replaced by a *group work contract*. Of course, such a contract causes various problems and it is in no way clear how to proceed. Nevertheless, the fact that work is more and more of a collective nature needs to be recognised by the labour law.

The increasing integration of managerial functions in normal work roles may have other consequences as well. It is sometimes argued that the employee is expected to act like an entrepreneur. These expectations, although very unclear, put high pressure on workers and demand increasing work effort, often resulting in *great amount of overtime*. On the other hand, contradictory to such expectations is the obligation of workers, to comply with the employer's orders. The ambiguous role of knowledge workers results in enormous stress. The above remark seems to indicate that work stress is a typical phenomenon of knowledge work. It is important to agree on work regulations that avoid extensive stress causing serious *health problems*. This should become an important topic in collective bargaining agreements.

Work at home or in other locations is becoming more widespread in knowledge work. A major problem still is whether people working at home belong to the group of paid workers or whether they are self-employed. The Finnish labour law is indefinite in this respect. Self-employment can have some advantages, such as independence and taking more responsibility. But not all people concerned have chosen 'self-employment' voluntarily; they are often forced to accept this new employment form. Although they have the status of an independent employer, economically they are not independent. Instead, *de facto* they work as employees dependent on decisions taken by the management of the company they are working for. The fact that the normally employed workers are replaced by the *'fictitious self-employed'* may become a major problem, as the latter are not covered by the protection mechanisms of the labour and social laws (Schienstock 2001). Labour is *losing institutional protection* and becomes increasingly dependent on individual bargaining conditions in a constantly changing labour market.

Restructuring of work processes has become a continuous process in companies. A major aim of restructuring is to make large companies more flexible and thereby improve innovation activities. Such lean production strategies, including the

elimination of tasks, flattening of hierarchies, and outsourcing of specific functions, often result in a reduction of the workforce. An increasing number of employees are at risk of becoming unemployed. The labour law provides some security, however. First, it states that the employee should be offered a job that corresponds to his professional skills and experiences; if this is not possible, the employee should be trained to be able to carry out new kinds of work. As restructuring of work becomes a continuous process, particularly workers' rights to regularly adapt their skills and competencies to changing demands needs to be strengthened.

Towards a company-based welfare capitalism?

The Finnish labour law hardly restricts flexible work, but it provides security for workers in atypical employment to some extent. Other aspects of flexible work are not regulated: work at home, wage flexibility, group work, project work, or virtual organisations. In some cases, regulations represent traditional perspectives but do not reflect new developments, such as increasing involvement of employees in management functions and unstable work careers during which people continuously change their employment status. The first aspect challenges to some extent the subordinate status of employees, while the second aspect challenges their obligation to refrain from competitive activities against their previous employers. In work careers, in which phases of paid employment, project contracts, and self-employment alternate with each other, the latter demand is hard to sustain.

The relative caution reflected in Finnish labour law towards regulating flexible work may have various reasons, related to the following aspects:

- a dynamic change in the economy makes it very difficult to lay down long-term regulations;
- while relationships between employers and employees were traditionally based on well-defined rights and obligations on both sides, in a knowledge society they are more based on trust, which makes regulations less relevant; and
- in a knowledge society, where workers are the owners of the most important production factor, they may need less protection.

We have already mentioned that the role of the state in the welfare system may change. But we can identify another aspect of the new type of welfare system emerging, which can be called '*company welfare capitalism*'. In this system, the state's role is to provide general conditions for *well-functioning employer-employee relationships* (job security, cooperation, and information). In addition, the state should empower employees through a sufficient general level of education and further training to participate in the regulation of their work corresponding to their interests.

Conclusion

In this chapter we have tried to demonstrate the role of the institutional setting for innovation activities. Networking between higher education institutions, such as universities or polytechnics, is important in order to accelerate knowledge diffusion within industry. We have highlighted the importance of skilled labour for transformation towards knowledge society. The techno-organisational restructuring processes that firms carry out to improve their innovation activities also increase the demand for flexible work regulations. And last but not least, in order to support innovation activities, the competion law needs to focus more on dynamic efficiency than on static, price-related efficiency.

It is, however, important to understand the two sides of innovation processes. This means that we have to understand better the role of the innovation system in the economy and in society at large. We need to focus more on the interaction among the innovation system, the science system, the legal system, the education system, the industrial relations system and the labour market. Aiming at improving the efficiency of a narrowly defined innovation system may overlook important feedback loops, which can cause enourmous costs, undermining the welfare effect of innovations in the long run.

Focusing on the role of the innovation system in the economy and society also opens up new perspectives for innovation policy. It has to be taken into account that innovations can be supported and hindered by numerous social and economic institutions that are not part of the narrowly defined innovation system. At the same time, however, policy makers must be made aware of the fact that innovations also have an impact on other parts of the economy and society. This perspective demands a new type of policy coordination which takes into account the interdependency between innovation policy and other policy areas. This new perspective on the system of the innovation approach suggests a new coordination of a broad set of policies including social policy, science policy, education policy, legal regulation policy, labour market policy and environmental policy (Schienstock 1999; Lundvall and Archibugi 2001). A broader innovation system approach suggests a new type of policy making based on policy networks, which will be discussed in the next chapter.

10 TOWARDS A NETWORK-FACILITATING INNOVATION POLICY?

The system approach is not only a tool for studying innovation processes but also a conceptual framework for governmental policy-making (Edquist 1997, 16). It provides a new understanding of the innovation process, which has major implications for innovation policy. While traditional innovation policy focused mainly on knowledge creation and the strengthening of the knowledge base, the systems approach suggests that innovation policy should primarily be concerned with *knowledge diffusion*.[88] The latter is socially and economically more important because it deals with *the huge stock of knowledge* that is exploited in production activities. It is based on the idea of systemic evolution which implies that, in order to generate economic growth, social development, and new jobs, knowledge has to be developed, diffused, and exploited throughout the whole economy (Ormala 1999, 117).

We will begin the chapter by discussing the traditional market failure argument for innovation policy, which focuses on the under-investment problem in basic knowledge creation processes. A modern innovation policy, we will then argue, needs to take into account all areas of *systematically weak performance* in the innovation system. This opens up a much broader perspective on innovation policy. Due to the interactive nature of modern innovation processes, governments will have to pay more attention to encouraging and supporting the communication, cooperation and networking processes among firms and their support organisations. We will present a framework that captures the main problems, issues, and phases of *network-facilitating innovation policy*. Next, we will discuss some international trends in the application of the network-facilitating approach identified by the

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[88] Here we understand innovation policy as a wider concept including science, technology, and innovation policy.

OECD Focus Group of Innovation Networks. We will compare these experiences with the network-facilitating activities of the Finnish Ministry of Labour and the National Technology Agency, Tekes. At the end of the chapter, we will discuss *benchmarking* as an important instrument for *policy learning* and analyse the networking challenges in the public sector.

Traditional technology and innovation policy

Traditional innovation policy mainly consists of science policy. Based on the cascade model of technological progress, it was assumed that the innovation process depends exclusively and linearly on the advances of natural and technical sciences. Traditional innovation policy was mainly concerned with the creation of new scientific knowledge by funding R&D efforts in a selected number of scientific fields. The rationale for this policy derives from the *market failure argument* (Arrow 1962b). Due to spillovers and high uncertainty, leaving basic research completely to the market would lead to under-investment in knowledge creation. There is too little incentive for companies to invest in basic research if third parties may gain access to the new knowledge without paying their fair share of the investments and if the potential returns take a long time to materialise and are highly uncertain. In addition, public support to basic research can facilitate the diffusion of new knowledge, which can stimulate innovation competition at the national level.

Traditional innovation policy is based on the principle that the further away from the market the research is, the more legitimate is the government intervention. There are, however, some exceptions to this principle in which the government extends its intervention to those stages of the innovation process that are closer to the market. In the case of large-scale technologies, for example, the transformation of scientific knowledge into marketable products cannot be managed by the market alone, due to problems of indivisibility and massive financial requirements (Arrow 1962b). Some countries have also used public funds to support applied research in military technologies. The development of international competitiveness has also been used as an argument for less restricted technology policies (Schienstock 1994).

Traditional innovation policy concentrates on supporting some key technologies in order to avoid technological dependency. This argument has been used to legitimate the set-up of large research institutes, which allowed the government to control the process of technology development in a bureaucratic way through direct interference. Traditional technology policy can therefore be characterised by *direct government control* over the dynamics of technological development through

and with bureaucratic professional organisations (Willke 1997). It gave the state a dominant role in the process of determining the path of technology development in the society.

While traditional technology policy is based on market failures, it is itself exposed to various *government failures*.[89] In the current context of great uncertainty, it becomes very difficult to select the technologies that promise best economic outcomes, and government agencies do not often have the necessary knowledge to decide which technologies will become successful and selected by the market. Due to the complexity and path-dependency of technological development, there is a great risk that traditional technology policy will lead to lower overall returns of public funds.

New rationale of innovation policy

The assumption that new scientific or technological knowledge will automatically stimulate innovation processes is too simplistic for modern innovation policy. As we have argued earlier, there is no linear relationship between new scientific and technological knowledge on the one hand, and the development of new products, services, and processes on the other. Instead, the process of technological change is becoming increasingly complicated. Different parts of the innovation process may become bottlenecks of the successful development of new products and processes. Therefore, innovation policy cannot only pay attention to basic research and market failures; policy makers also have to ask a more general question of *where* and *how* the performance of the innovation system is weak (Edquist 1997). All such 'systemic failures' are *potential* targets for government intervention (OECD 1998). Whether or not government intervention is the most effective way to address a specific systemic failure (incl. market failures) depends on the relative organisational strengths and weaknesses of the government *vis-à-vis* possible private or third sector arrangements (Hämäläinen 2001).

The transformation of the world economy and the complex and interdependent nature of modern innovation processes pose major challenges to innovation policy. A dynamic, highly interdependent and complex innovation system can suffer from many different types of systemic failures (Smith 1997; Lundvall and Borrás 1997; Schienstock 1999). These failures may be related to any part of our competitiveness framework - productive resources, technologies, organisational arrangements, product markets, international business activities, institutional framework and government activities — and the transformation capacity of the innovation system. In the following, we will give a few examples of such failures:

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[89] For a comprehensive discussion of different government failures, see Hämäläinen (2001).

Infrastructure failure. This failure stems from under-investment in physical (communication and transportation technologies) and in knowledge (universities, libraries, public research institutes, etc.) infrastructure. There are two alternatives for public intervention: direct public provision or setting up incentives and control mechanisms for private provision.

Organisational failure. Firms may be unable to transform their internal organisations and stick to the old Fordist production model instead of turning themselves into learning organisations[90]. Here public intervention can, for example, initiate organisational restructuring processes, support the intelligent use of modern ICTs, stimulate human capital development, and encourage the use of knowledge-intensive business services. Another organisational failure relates to inter-firm cooperation. For reasons to be discussed in Chapter Ten, firms are not always able to build social capital, form networks and other cooperative relationships without external help. Potential "network facilitation policies" will also be discussed in Chapter Ten.

Structural market failure. Structural market failures may relate to the anti-competitive behaviour of firms or excessive government intervention in markets (Dunning 1992). Both factors may reduce product market competition below the socially optimal level. Competition is a key incentive for innovation (Porter 1990), though excessive competition may leave too little resources for innovative activities (Lawrence 1986). Structural market failures are typically addressed with competition policies. As we have discussed above, the need for close cooperation in modern innovation processes poses new challenges for competition policy, which must balance the static and dynamic efficiency arguments.

Institutional failure. The institutional and regulatory framework tends to change rather slowly and, hence, may become a hindrance to firms' innovation activities (Määttä 2001). There is a need to continuously monitor and assess the functioning and performance of the institutional setting and regulatory framework.

Transformation failure. As we discussed in Chapter Three, systemic transformation is not easy. The established mental models, distribution of resources, and power relations may block structural change and new innovations (Hämäläinen 1999). Basic research, cross-sectoral and international cooperation, public discussion fora, as well as the extensive use of KIBS may offer some policy instruments to overcome such *systemic rigidities*. Besides understanding and motivation, the change process also requires coordination among the different parts of the innovation system. Policy makers may try to coordinate systemic adjustment and innovation by creating a shared vision and by establishing cross-sectoral discussion fora around key adjustment challenges.

The new systemic perspective has inspired new directions of innovation policy. During the 1980s, the policy makers moved away from direct innovation policy toward framework conditions. Indeed, we can talk about a new *innovation-enabling policy approach* (Schienstock 1994; see also Metcalfe 1997). The key idea of this

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[90] See Chapter Seven.

approach is that technological competitiveness depends on the strength of the whole economy, not just the development of specific technologies. This implies a move away from selective policies and the development of conditions that are common to all industries and technologies.

Innovation-enabling policy may not always produce the expected results, however, as framework conditions will affect different types of firms differently (Lundvall and Borrás 1997). As a result, there has been an increasing emphasis on *industrial clusters* in innovation policy. This is a compromise between the development of general framework conditions and the more specific framework conditions of particular groups of companies. Recently, as interaction and cooperation has become increasingly important for innovative success, policy makers have also begun to develop policies for creating and facilitating inter-organisational networks.

The network approach to innovation policy[91]

"Networks", as the OECD states, "are an important component of national systems of innovation. An important function of science and technology policy is to strengthen existing innovation-related networks and to help build networks in areas where they are lacking" (OECD 1992, 79; see also OECD 1998a). The growing importance of cooperative networks has also been recognised by governments in recent years. They have developed many different types of policy measures to facilitate the creation and efficient functioning of inter-firm networks. However, these government interventions have not been based on a sound theoretical framework of government role in network facilitation. Indeed, there is not yet a well-developed theory of network policies available (Hyötyläinen 2000).

The traditional theories of government intervention were not developed with network facilitation in mind[92], and the research on networks has paid very little attention to policy questions. The scholars of innovation systems have recently moved toward a new policy paradigm that is more relevant to network facilitation. But they are not very clear about the key problems that governments should address and, more importantly, about the division of labour among government,

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[91] This and the next section are based on the paper "Innovation networks and network policies" by Hämäläinen and Schienstock (2000). This paper was prepared for the OECD Focus Group on Innovative Firm Networks.

[92] These theories come from multiple subdisciplines of economics such as neoclassical, development, welfare, and new institutional economics. For a comprehensive review, see Hämäläinen (1999).

third sector organisations and firms in addressing such problems (see Lundvall and Borrás 1997; OECD 1998a, 1999).

As institutional economists have shown, the existence of a governance problem does not automatically call for government intervention (Coase 1960). Other organisational solutions - such as markets, corporate hierarchies and third sector organisations - should also be examined. In particular, problems in networking can sometimes be solved more efficiently by large firms (hierarchies) and business associations (third sector) than by government intervention. Since all organisational arrangements involve their own strengths and weaknesses economic efficiency requires that different types of governance problems should be addressed by those organisational arrangements which have a comparative advantage in solving them in a particular social context (Hämäläinen 1999).

Due to the scarcity of research on network facilitating policies, policy makers know very little about:

(a) the conditions, in which network arrangements are more efficient than alternative organisational solutions;
(b) the types of problems or 'failures' that are typical in setting up and operating networks; and
(c) which of these problems could most efficiently be overcome by governments.

We analysed the first question in Chapter Eight. We will address the latter two questions below. The systemic responsibilities of government in modern innovation policy do not mean that it should more actively intervene in the economy. As we noted above, the government's role is limited by the comparative advantage of private- and third-sector organisational alternatives. In the present context, governments should worry about the problems in networking but only to the extent that they can provide superior solutions to those of the private and third sectors (e.g. large corporations and business associations). Unfortunately, there are no rules of thumb for deciding the efficient division of organisational labour among different organisational alternatives (Coase 1990). The best organisational solution must be found separately in each practical context by comparing the actual strengths and weaknesses of the available alternatives.

Matching policies to stages of networking

The process of creating a cooperative network involves many practical problems. The costs of solving these problems tend to fall on the organisation that takes the initiative in network formation. These costs stem i.a. from the process of finding

out the right partners, negotiating with them, creating behavioural rules for cooperation and building the necessary shared resources. However, the benefits of a well functioning network tend to diffuse to all members of the network. Thus, the formation of networks suffers from a *public good or externality problem*: the private benefits from network formation may not cover the private costs, though social benefits might well do so.

Only when the private benefits of setting up a network exceed the private costs will a rational firm engage in network formation. If this is not the case, and a market solution fails, there may be room for efficiency enhancing government intervention. However, business associations and other third sector organisations (chambers of commerce, centres of excellence, etc.) may also provide efficient solutions to the externality problem.

The practical problems of networking change in different phases of the networking process. The following analysis of such problems will follow the phases of a typical networking process: (a) firms' awareness of networking opportunities, (b) search for partners, (c) building trust and shared knowledge base, (d) organising the network, (e) adding complementary resources, and (f) stabilisation of cooperation (see also Hyötyläinen 2000). We will pay particular attention to problems which create a wedge between the private and social benefits (and costs) of networking.

Creating awareness. Despite wide media coverage and active promotion by different policy makers, the nature and potential benefits of network cooperation are not always very well known and internalised among small firms. Entrepreneurs are often too busy to consider and test new business models and may even be afraid of losing their competitive advantages to prospective partners. This *information problem* may slow down organisational adjustments among firms that could benefit from active network cooperation. Governments and third sector organisations can promote firms' awareness about networking e.g. by arranging seminars and distributing information about it and by trying to get the media to cover successful examples of networking. The fact that network cooperation is not a panacea to all organisational problems should be borne in mind in all network promotion.

Searching for partners. Finding out appropriate partners for cooperation involves another information problem. The best partners for highly specialised firms may be located in another town, region or even in a different country. A recent survey of manufacturing firms in Finland showed that the most important reason for *not* participating in cooperative networks is that there are no suitable partners available or they are difficult to find (TT 2001).

Governments can support firms' own search for network partners with information, brokerage and matching services (Lundvall and Borrás 1997; Narula and Dunning 1999). Such services can be arranged with trade fairs and business seminars or they can be provided with modern information technologies. For example, the European Union has web-based matching services that cover the whole EU-area. Policy makers can also subsidise small firms' travel expenses to foreign fairs and seminars where new partners can be found (Miettinen et al.

1999). Besides firms, successful networks often involve other types of organisations such as universities, research institutes, government agencies, etc. These organisations can be direct participants or provide important complementary resources for the network.

The above policy measures assume that firms actively participate in government programmes. This may not always be the case. Especially small firms are often too busy with their daily business or simply lack the financial or human resources to find out and participate in different networking initiatives. As a result, many potentially beneficial networks are not created without more active policies and encouragement.

Finding out potential networks and partners is not easy. It requires deep knowledge about firms' specific strengths and weaknesses and how they could complement each other (Lundvall and Borrás 1997, 112). This suggests that the search for potential network partners should take place very close to firms at local and sectoral levels. Besides the firms themselves, local authorities and business associations could play a key role in this process. Practical experience suggests that network policies should not aim to create new networks from scratch: network promotion could be focused on emerging but fragile networks, which require further encouragement and support. This will minimise the potential for government failure.

Building trust and shared knowledge base. Once appropriate partners have been found there may still be many mental barriers to effective cooperation. In fact, the mental rigidities and old behavioural routines of entrepreneurs are often the biggest hurdle to effective networking. Potential partners need to learn more about each others' world view (cognitive frame), beliefs and attitudes, values, business strategies and operating methods. This can only be done through an intensive and open discussion in which the participants gradually build trust and a shared knowledge base (see also Hyötyläinen 2000). Being a neutral and trusted "third party", governments can often reduce the suspicions and reservations that firms have toward closer inter-firm cooperation.

Building shared understandings and trust takes time. As a result, governments should favour policies which provide firms adequate incentives to continue participating in the networking process long enough to build the necessary shared knowledge base and social capital. Setting up long-term network facilitation programmes and building inter-firm meeting arenas may be more productive than trying to more directly match potential partners who have not had enough time to learn to know each other well nor build the shared understandings and trust. One example of such a long-term process is the British technology foresight programme that has resulted in active network formation among the participating firms and other organisations (see www.foresight.uk.gov).

Taking into account the time and resource constraints of small firms, government programmes should preferably offer some additional benefits beyond the uncertain advantages of networking. Often, emerging cooperative networks can only become sustainable if they can provide the participating firms tangible benefits in the not

too distant future. For example, the foresight method could well be used to support the strategy formulation process of networks. Besides the long-term benefits of cooperation, firms would get an easy access to well-analysed information about major changes in their business environment.

The intensive inter-firm communication required for trust-building can also be facilitated by shared information infrastructures, such as network-specific extranets or internet pages. The provision of such public goods could initially be supported by governments in the case that benefits of networking can only be expected in the longer term.

Organising the network. Once firms understand and trust each other enough, they can start to build a *shared vision, strategy, structure* and *behavioural rules* for the network. A shared vision of the future and a common strategy are important co-ordinating mechanisms in highly specialised and interdependent networks where the market mechanism or hierarchical coordination cannot be relied on. The efficiency of network coordination is a major challenge even for well-established networks. In the recent Finnish study on industrial networks, different types of coordination challenges were the dominant problems in established networks (delivery delays, large variations in capacity utilisation, logistical inefficiencies, inflexibility of the production process, problems in project management, communication problems in the production process) (TT 2001).

However, these coordination mechanisms do not emerge automatically; someone has to provide the leadership in their development. This role is often played by a strong "flagship firm" which has a keen interest in the success of the network (Rugman and D'Cruz 1996). Indeed, in the search stage of network formation, government activities could focus primarily on finding such flagship firms. The other partners could then be sought in cooperation with these firms.

Even in the absence of a flagship firm, governments can support inter-firm coordination by providing institutional arenas, such as the Japanese "deliberation councils" (World Bank 1993) or the Finnish cluster programmes, for intensive inter-firm communication. The task of building a shared strategy for the network could also be explicitly included into public networking programmes. Lacking detailed business knowledge, governments should try to avoid undertaking the coordination task themselves.

Governments can also support the actual organisation of the network and its business processes by providing information about potential problems and best practices in network cooperation. It can also develop contract models and arrange consulting services to help structuring the network. However, governments should be very careful in expanding their subsidised consulting services because there are well-functioning markets in organisational consulting.

Adding complementary resources. Emerging new networks do not often have all the key resources and capabilities required for competitive success. For example, a key technology or other input may not be available from the existing network partners, or the network could lack access to important foreign markets. As we

have discussed before, such systemic failures could relate to any part of the network's value-adding system and its socio-institutional environment (OECD 1999), such as *resources* (e.g. human, financial, infrastructure), *technologies* (ICTs, specific technologies), *organisation* (intra-firm organisation, incentive systems, etc.), *product markets* (sophisticated demand, product market regulation, competition, etc.), *international business activities* (access to foreign markets, technologies, business systems, etc.), *institutions* (laws, regulations, norms, customs) and *policy framework* (public sector organisations and their activities).

The problem of missing complementary resources is familiar from development economics. Many development economists have emphasised the problem of building a mutually reinforcing business system in developing countries (Rosenstein-Rodan 1943; Hirschman 1958). Missing key resources can create negative external effects through "forward and backward linkages" in the interdependent business system. This calls for explicit coordination of development investments, or a "big push", throughout the system (Rosenstein-Rodan 1943; Richardson 1960). On the other hand, fixing the systemic failures may release the positive externalities of a network and lead to increasing returns and sustained competitiveness (Arthur 1994; Hämäläinen 2001; see Chapter Three).

Local, sectoral, national and international network policies

The specialisation, dynamism and social embeddedness of networks makes network facilitation a demanding challenge for policy makers. Sophisticated interventions require deep knowledge about the relative efficiency of different organisational alternatives, specific strengths and weaknesses of potential partner firms and peculiarities of the local socio-institutional framework. Local and regional governments and industry associations may have information and knowledge advantage over national and higher levels of government (such as the EU) in this respect. Moreover, since the feasibility of carrying out complex inter-firm cooperation declines with geographical distance and increasing knowledge diversity the preconditions for successful networking are also best at these levels (Scott and Storper 1986, 26). The situation in low-tech and high-tech industries might differ significantly, however, as in the high-tech sector it is often very difficult to find the critical mass of knowledge concentrated in one region, particularly in a small country like Finland.

Despite the importance of geographically concentrated production networks, we cannot neglect that networking also takes place at the national and international levels. For example, cross-border technology alliances have grown very rapidly

since the 1980s as firms are seeking firm-specific complementary knowledge from all around the world (Narula and Dunning 1999). Moreover, for Finnish manufacturing firms, geographical proximity and same nationality are the *least* important factors in the choice of their network partners (TT 2001). Therefore, no single actor can take the full responsibility for network facilitation policies since the different levels of government and types of third sector associations are often involved with different parts of the same inter-firm networks.

National policies can focus on creating the right framework conditions for the network facilitation activities of local/regional governments and industry associations. This could involve changes in the regulatory framework or financial support of local networking programmes, for example. Many important complementary resources of networks - such university research infrastructure, internationalisation services, etc., are also most efficiently provided by national governments. National governments could also coordinate the various local/regional policies, activities of industry associations and the programmes of different government agencies and connect national networks to foreign markets and networks.

The local/regional governments and industry associations are not always aware of the potential benefits and risks of networking and the emerging best practices in network policy making. They may also lack the appropriate knowledge and training for conducting effective network policies. Hence, national governments could set up programmes that transfer the necessary knowledge and skills about networking to these organisations.

National governments can also support the network facilitation policies of local/regional governments and industry associations by undertaking future oriented programmes, such as technology foresight and assessment, which provide local policy makers and industry associations with useful tools in their networking activities. As we have noted above, foresight processes and materials can be used to attract busy entrepreneurs to participate in networking processes. Such future-oriented processes will also help the local policy makers to build realistic and anticipatory policy visions.

Finally, when inter-firm networks cross national borders, as they increasingly do today, national governments can use their international networks to facilitate effective international cooperation. They can, for example, search foreign partners to complement the knowledge and resources of domestic networks, distribute information about potential foreign markets, and arrange access to multinational research networks and programmes. These foreign activities need to be closely co-ordinated with the network policies pursued at the national, local/regional and industry levels.

International approaches to network-facilitating policy[93]

Network-facilitating policies differ significantly from country to country. They can involve *different types of actors* (firms, universities, government agencies, business associations, etc.), *geographical dimensions* (local, regional, national, international), *industrial sectors*, and *phases of the innovation process* (basic research, design, international marketing, etc.). Network policies can also be cross-sectoral, involve many different geographical dimensions and cover most activities in the value system.

In many countries, however, network-facilitation has only recently become an issue in innovation policy. Governments have only little experience with such policy measures and they cannot base their policy on sound empirical evidence since there are hardly any evaluations of network policies available, yet. Policy measures aimed specifically at networking are a particularly recent phenomenon. Some countries have experience with programmes which have cooperation and networking as a secondary goal. However, many countries are investing more resources to stimulating and supporting innovative networks.

Although we have stressed the diversity of existing networks, a clear policy focus seems to be on *science-industry relationships* which foster collaborative knowledge creation and accelerate knowledge diffusion. Universities play a key role in such programmes. Another priority in network-facilitating policy is the *cooperation among SMEs or between them and larger companies*. In general, the programmes emphasise *flexibility*: they have only *minimum formal requirements*. In most cases, the management of the network is left to the cooperation partners. Government agents only give organisational or administrative help and they provide different kinds of information. While the *technological dimension is dominating*, some programmes also include aspects of organisational restructuring and human resource management.

There has recently been a shift in the design of network programmes. While top-down strategies with predefined technology areas and 'strategic industries' dominated earlier programmes, today governments increasingly apply a *bottom-up approach*, *encouraging self-organising networks*. Governments seem to consider themselves more as facilitators and enablers, rather than as doers (Schienstock 1994).

Due to their short history, it is not possible to identify the overall impact and success of the network-facilitating policies. However, there are some preconditions, which seem to make success more likely. *Time* is a critical resource in networking because it is time consuming to build up a shared frame and high-trust relationships

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[93] This section is based on the Summary Report of the Focus Group on Innovation Networks by Schibany and Polt, Vienna, 2001.

among potential network partners. As we have argued before, these two factors form the critical basis for smooth and effective cooperation. Programmes of short duration (e.g. 1 to 2 years) seem to produce limited results: networks do not emerge or they break apart after the programme.

While financial support is a useful incentive in getting companies together, it does not guarantee their active participation and involvement. Companies are only interested in *long-term cooperation* if programmes are designed with a clear goal to produce positive results for the network members. Particularly if SMEs are involved it must be guaranteed that they can benefit from cooperation. Hence, the policy initiatives must be tailored to the specific needs and capabilities of the potential network partners.

Most of the programmes do not cover all aspects of the innovation process. Some may focus on collaboration in knowledge creation, others on the development of a new prototype, and a third may support human capital development. There seems to be a need to *co-ordinate different programmes* more intensively as companies are often not aware of complementary financing. Also, programmes launched at different geographical levels need to be co-ordinated, not necessarily to avoid overlap but to support a more systemic approach.

Network-facilitating policy in Finland

So far, a *holistic approach* towards a network facilitating innovation policy has not emerged in Finland, although organisations in this country have longer experimented with this approach than most other countries. This might also explain, why innovative companies cooperate quite extensively in Finland more than in most other countries [94] (Foyn 2000**).** Several ministries, public agencies and business associations are active in this field. The Ministry of Labour and the National Technology Agency, Tekes as well as the Academy of Finland are the most important organisations in Finnish network-facilitating policy.

Particularly the strong cooperation between Tekes and the Academy of Finland is quite unique in Europe. The basic idea behind this close cooperation seems to be that scientific and technological knowledge emerge together in university/industry networks. It reflects the fact that particularly in high-tech industries, basic scientific research is nurturing innovation and that the boundaries between basic and applied research are becoming increasingly blurred. Since we will concentrate on inter-firm networks in the following, we will only refer to the network-oriented programmes of the first two organisations; we will briefly describe those below in the light of our previous analysis.

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[94] Here we refer to the data from the Community Innovation Survey (CIS).

National workplace development programme

The Ministry of Labour in Finland has promoted inter-firm and inter-organisational networking since 1996 as a part of its National Workplace Development Programme. The aim of the programme is to boost productivity and to improve the quality of working life by supporting the development and utilisation of knowledge and innovations at Finnish workplaces. The budget of the programme was FIM 95 million for the 1996—1999 period and it is currently an important part of the Finnish government's strategy.

The development projects of the programme are facilitated by organisational researchers, who bring their theoretical, empirical and contextual knowledge to help in the practical problem solving situations of networks. They also model the problem situations and their solutions, which is important for the diffusion of the accumulated knowledge.

The programme gives priority to projects aimed at bringing about a comprehensive change in work organisation. This may involve technologies, organisational forms, leadership, vocational and professional skills, working conditions and occupational health issues. The programme supports projects initiated by companies and public-sector organisations. The projects may come from any sector and they do not need to be limited to specific workplaces. However, both management and staff should be committed to cooperation and the project's aims.

In 1996, the Science and Technology Council of Finland allocated FIM 30 million for the National Workplace Development Programme. The aim of this additional funding was to launch new network facilitation activities and projects. These networking activities also became a part of the eight cluster programmes initiated by the Council.

The network facilitation activities of the programme involved 13 networking projects and about one hundred organisations between 1997—1999. About 80 percent of these organisations were manufacturing firms but some government organisations were also included. The projects involved both vertical and horizontal networks; both small and large organisations were involved. In most projects, the Ministry of Labour was not the sole source of funding, others included Tekes, ESR, other ministries, etc.

The network facilitation policies of the National Workplace Development Programme are based on the recognised need for a systemic transformation within and among interdependent organisations. As we have shown, both technological and organisational innovations are needed for good performance and sustainable development. The main goal of the networking projects is to promote the systemic transformation of firms and other organisations towards learning organisations and learning networks. Moreover, as noted before, the researchers develop a conceptual model the networking process for future use.

The specific problems or failures, which the network facilitating policies aim to overcome, include:

(a) lack of information about the potential benefits of network cooperation in organisations (information problem);
(b) difficulty of implementing systemic change in organisations and networks (perhaps due to lack of shared understanding, trust and vision);
(c) uncertainty about the ability to reap the benefits of human capital investments (required complementary resources); and
(d) structural, institutional and mental rigidities in the organisational environment (systemic failures).

The government intervention has influenced the different phases of the networking process in the following way.

Awareness creation. The policy makers used *publications, seminars and the Internet* in order to create awareness about the potential benefits of networking and the policy instruments available for that purpose.

Search for partners. The programme did not participate in the search of potential partners, it was the responsibility of the applicants to the programme to find their partners. However, it was recognised that this may leave some potential networks and partnerships undeveloped (particularly in service sectors) since small firms often do not recognise the benefits of network cooperation. Reaching such firms may require an active contribution from regional and sectoral players. The information of regional T&E-centres was, however, used in the selection of projects by the Ministry.

Building shared understanding and trust. Often in cooperation with a flagship firm, the researcher made *basic analyses of the network's strengths and weaknesses* and arranged *development discussions and workshops* with the network's participants. In horizontal networks, *benchmarking seminars* have provided a shared base for learning. All these methods build the network's shared understandings and trust.

Organising the network. The organisation of the network has often taken place parallel with the building of shared understandings and trust. It involves *interactive workshops and seminars* where the researchers and members of the participating organisations build a shared vision and strategy for the network. The network vision and strategy are then turned into *practical development goals and targets for the network*. Achieving these goals and targets becomes the task of *inter-organisational development teams*. The organisation of the network also requires shared behavioural rules, which are cooperatively developed at this stage.

Complementary resources. The networks have not been complete without some additional resources and development efforts. The personnel of the participating organisations have often required *training* in the new organisational processes and methods. *Intra-organisational structures and operating methods* have also needed adjustment. The cooperation has been facilitated with *shared information infrastructures* and *cooperative cost accounting methods*. The network has developed and acquired these complementary resources with the help of the programme.

It is too early to say anything definitive about the results of the network-facilitating policies since many of the projects are still continuing. However, it seems clear that external assistance in networking helps the organisations to overcome many practical problems in networking.

Building shared understandings, trust and the vision and strategy for the whole network takes time. Thus policy makers should be patient enough to give the participating organisations a fair chance to learn to cooperate with each other. Successful cooperation will take considerable time to mature.

The method of research-assisted networking has considerable benefits. It not only builds the conceptual models for further dissemination of the results but also puts the projects into wider social and research perspective. There is a clear *need for more well-trained researchers and consultants* in Finland who can effectively facilitate inter-organisational networking. There is also a *clear need for increasing cooperation among network policy makers* in different ministries and public agencies in order to spread the best practices and foster mutual learning.

Tekes' technology programmes

Ever since Tekes launched its first technology programme, the aspect of cooperation and network formation was always included in the funding policy. This means that Finland has longer experience with this type of policy than most other European countries. Tekes applies the network concept in a wider policy frame than is the case elsewhere.

Tekes supports *different types of networks* in its various technology programmes: cooperation among R&D institutes, pre-competitive horizontal cooperation among companies, as well as vertical cooperation and networks of SMEs with larger companies and with R&D institutes. Tekes' programmes aim to cover the *whole value chain from R&D to marketing*. Tekes takes a bridging function between public and private research institutions and industry and particularly between universities and SMEs. From the firm perspective, Tekes' programmes provide an easy access to existing knowledge, while research institutes appreciate the ability to sell their research and knowledge to firms. Large companies cannot get Tekes financing without cooperating with either small companies or research institutes. The rationale behind this is that large companies should buy more research from research institutes and that they should share their knowledge with small companies. It is important that, in all programmes, companies have to provide some funding; on average about 50 percent of the funding come from Tekes. Only if the research is of strategic value will Tekes provide 100 percent financing.

In the beginning, the fact that companies participating in the programmes were prepared to contribute to the financing of the project was seen as a decisive criterion. It was expected that only those companies would participate in the projects that were convinced of the quality of their technology and of the market opportunities of the new product. Nowadays, Tekes monitors the programme

participants more carefully to make sure that the cooperative partners have the absorptive and transformation capabilities to benefit from the cooperation. This implies that not only the technologies and the international market potential are analysed, but *companies are evaluated as a whole*: the financial structure, the knowledge base, and the management. The idea is to identify weaknesses, which may require additional support.

Tekes is increasingly interested in supporting *international cooperation* with research institutes in the USA and in Japan. During the 1980s and up to the mid-1990s, the focus was on Europe to help Finnish companies to become engaged in EU programmes. Since Finnish companies were quite successful in becoming involved in European projects, Tekes now aims at quality instead of quantity, which means that Finnish companies and research institutes should become *co-ordinators of projects*. Concerning international cooperation, Tekes has clear rules: if exchange of researchers takes place it must be a part of the project. Foreign researchers should come to Finland but also Finnish researchers should go abroad. Such researcher exchange is an effective way to build international networks that may subsequently lead to innovations (Miettinen et al. 1999).

For a small country like Finland, the strong international focus is very important, as most of the knowledge needed in Finland is produced elsewhere. Only few countries stress the aspect of international cooperation and networking in innovation processes to such an extent as does Tekes. Compared to other countries, Finland is comparatively liberal with respect to funding international cooperation, but considerable social and commercial benefits have to remain in Finland, since the stay of R&D in Finland is one way to secure social and commercial benefits.

Tekes' network policy is *'bottom-up'*-oriented, but it also contains a strong support element. The policy is to encourage and consult companies but not to give direct instructions: the decision to participate needs to be made by the companies themselves. In principle, Tekes sticks to the concept of *self-organising networks*. As technology support often implies the rebuilding of the value chain, Tekes helps to find the missing links in the chain.

Tekes is cautious, however, about not going too far in its network-facilitation policies and hence restricts itself to encouraging, advising, and pointing out where potential partners are. It demonstrates how networking works and what kinds of problems may come up. Tekes tries to keep the barriers to networking rather low by supporting the learning processes of firms. Therefore, networking often starts with some activities that are not directly business-related.

As Tekes focuses on technology support and does not help in organisational and training matters, it tries to intensify cooperation with other institutions in order to utilise their knowledge and activities (e.g. Ministry of Labour and Ministry of Education). Also, venture capital organisations such as Sitra are included in the programme planning and evaluation processes. Moreover, the cooperation between Tekes and the Academy of Finland has become increasingly active in recent years. Parallel research programmes are often launched and the two institutions are developing some programmes together.

Tekes is very aware of the network failure[95] that organisations are fixed too long a time to specific networks, which might lead to rigidities in the network. Tekes therefore introduces new technological opportunities or new application areas from time to time together with a partly renewed set of actors to keep the networks developing. This is particularly important as far as R&D is concerned, where new ideas and innovations typically come from multidisciplinary interaction. Today Tekes typically implements programmes which last three to five years; afterwards a set of new programmes is launched, which means that earlier participants get involved in new projects and programmes in a slightly modified combination of actors. This allows organisations to continue developing networking with various partners but also keeps bringing them together with new partners. Through such a strategy, Tekes achieves both the deepening of collaboration and the renewal of networks.

Benchmarking and policy learning

The national innovation system approach is a loose conceptual framework, which does not in itself provide a sufficient basis for developing innovation policy (Edquist 1997). It is not focused enough to suggest concrete policy measures. The political relevance of the systems approach stems from the *comparative method*[96]. Only in connection with comparative analysis can the systems approach become politically relevant. By comparing various national innovation systems and their institutional structures, policy makers may be able to *identify good practices and new tools* which can then be 'borrowed' to improve the innovative and economic performance of their own countries (Freeman 1987). The ability to identify, analyse, adapt, diffuse, and use technological, economic and social innovations developed abroad is an important capacity for both catching up and leading countries (Johnson 1997, 38).

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[95] Network failures are discussed in Chapter Eight.

[96] Miettinen (2001) suggests distinguishing between a systemic-causal or holistic approach and a comparative approach. The systemic-causal approach regards it possible to define all the relevant factors or determinants affecting technical change and tries to form a systemic model of these factors (see also Edquist 1977, 2, 5). A comparative approach studies the national differences of innovation-related institutions and their interactions and tries to learn from the results. As Miettinen rightly argues so far, systemic-causal explanations have not been achieved. The evolutionary theory, on which the system approach is based, does not aim at causal explanations but at identifying processes of co-evolution.

Today there is a rapidly growing policy interest in various forms of *'benchmarking'*, comparing internationally the performance of institutions. This interest can be explained by the fact that governments increasingly realise the benefit of institutional adaptation and learning. The application of the traditional benchmarking method to national innovation systems is difficult, however. First, the identification of good practices or institutional settings depends on whether their efficiency or effectiveness can be measured. So far, there seems to be little agreement on how to measure the efficiency of innovation systems (Carlson et al. 1999). Second, it is even more difficult to identify the contribution of a specific institutional solution to the outcome of an innovation system as a whole. Third, one cannot expect that an institution, having evolved as a part of a specific innovation system, would function in the same way and with the same efficiency in another system. Indeed, the advantage of the innovation system approach stems from the fact that it does not relate economic success to isolated factors but to the quality of the system as a whole.

As a result, a looser form of benchmarking may be helpful to better understand one's own innovation system, its strengths and weaknesses. We may speak of *intelligent* instead of *mechanistic* benchmarking. As Nelson and Rosenberg argue, we may *learn from diversity* (1993, 2). Systemic benchmarking requires a process of institutional learning and adoption to the new system (Lundvall and Borrás 1997, 63).

Indeed, in the context of a major transformation, we can characterise innovation policy as a *process of policy learning* (Johnson 1996, 18). Such an interpretation is quite different from the traditional conceptualisation of innovation policy, which interprets it as a decision-making process, consisting of the following three stages: setting goals, developing programmes, and implementing projects (Schienstock 1999). Such an approach separates decision-making at the policy level from concrete change processes, as it assumes some kind of automatic change process. "The learning approach, on the other hand, provides a fluid perspective of a policy process in continuous transformation and evolution where no clear stages can be discerned" (Lundvall and Borrás 1997, 64).

Besides benchmarking, such policy learning can be facilitated by policy evaluations and technology foresight and assessment studies (Lundvall and Borrás 1997). While there is an active policy evaluation culture in Finland and also benchmarking has been used intensively for several years (Oksanen 2000), technology foresight and technology assessment have not been systematically used to support policy learning. Particularly, the foresight method offers great opportunities for network-facilitating policy. It could also be used to overcome mental rigidities that block structural adjustment and social innovations in key areas of the society.

Networking in the public sector

During the immediate post-war decades, rigid hierarchical structures worked quite well in the organisation of public sector activities. In all industrialised countries, the public sector was much smaller and less-specialised than today, the technological and economic environment was rather stable, and steady economic growth and growing fiscal revenues helped to cover most public sector inefficiencies. However, in the late 1970s and especially during the 1980s, the dynamic forces of the world economy began to raise the coordination costs of both private and public hierarchies. Today, the coordination of interdependent activities is a key challenge to public sector organisation and management in industrialised countries (Peters 2000), including Finland (Bouckaert, Ormond and Peters 2000).

The growing popularity of quasi-market solutions and partnerships between firms and public sector organisations also suggests that public sector hierarchies face similar organisational challenges as their private counterparts (see Chapter Eight). Indeed, due to their generally larger size, the organisational adjustment pressures on public sector hierarchies are likely to be stronger than those on private hierarchies.

Public organisations have been challenged by the same dynamic forces as their private sector counterparts. The growth and specialisation of public sector activities has made them increasingly interdependent. This has created important cross-cutting policy issues and areas — such as environment, competitiveness, education — where public policies cannot easily be co-ordinated within traditional "stovepipes" of government (Peters 2000). The coordination costs have also been raised by the increasing specialisation of public sector knowledge and organisational cultures which reduce the effectiveness of communication between related organisations. Furthermore, the systemic adjustment needs of societies - which are caused by the rapidly changing techno-economic environment - have created additional coordination challenges for public sector organisations (Hämäläinen 2001).

As we have seen, the growing coordination problems of public sector organisations require stronger coordination mechanisms than rules and regulations or hierarchical planning. Moreover, the earlier strategy of decentralisation and disaggregation of public sector activities is not sufficient anymore. In terms of Figure 7 in Chapter Eight, horizontal coordination must increasingly rely on mutual adjustment as well as shared vision, strategy, understandings and values. This is a major challenge for governments who have traditionally focused their creative energies in finding new and more efficient hierarchical coordination mechanisms and structures (for a good review, see Peters 2000). Besides the visionary leadership of the top policy makers and the horizontal day-to-day coordination of civil servants and other public sector employees, an efficient and innovative public sector also requires effective vertical communication and coordination among the different levels of government. Otherwise the visions and strategies lose touch

with the realities of grass-root policy making and the former are not effectively communicated to all public sector employees.

The growing specialisation of public sector organisations has also made their resources and knowledge increasingly specific and dissimilar from other public and private sector organisations. As a result, the necessary complementary resources and knowledge often lie in other public or private sector organisations. If such resources and knowledge are supplied by multiple competing private sector organisations the public sector organisation can acquire them through competitive bidding or *"quasi-markets"* (Le Grand and Bartlett 1993). On the other hand, if there are only few specialised suppliers, closer cooperation and coordination in the form of *public-private partnerships* (PPP) may be called for. Quasi-markets and PPPs are typically used in the provision of public services.

Private quasi-markets and PPPs can also be used in the commercialisation of certain public goods, such as basic research or infrastructure. The growing patenting and licensing activities of universities and their increasing cooperation with firms in basic research are good examples of such activities (Nelson 2000; Lennon 2001). Similar to the sector example, the quasi-markets use the price mechanism for coordination whereas the public-private partnerships call for cooperative planning, mutual adjustment together with shared visions, strategies, understandings and values.

If the public-private cooperation involves policy making or implementation, PPPs are often called *"policy networks"* (Schneider and Kenis 1996, 42). Such networks can utilise the knowledge and capabilities of widely dispersed actors in different sectors and levels of the society.[97] Policy networks can also help the creation of collective vision for the society and commit the key stakeholders to implementing the chosen strategies. On the other hand, they can also tie the hands of policy makers if the necessary decisions would threaten the interests of some key players in the network (Olson 1982). This may slow down the society's structural adjustment process during a techno-economic paradigm shift.

As noted earlier, the organisational reality is more complex and dynamic than the "ideal type" organisational alternatives might suggest. Private and public hierarchies have responded to the organisational challenges also by introducing market and network elements *within* themselves. Most large firms in dynamic industries actively use horizontal coordination and flexible network arrangements in their internal operations. Public sector hierarchies have more experience in introducing market-based mechanisms and pricing for their internal service relationships (see e.g. OECD 1994). Such hybrid solutions require very skillful and difficult balancing of the features of different organisational alternatives.

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[97] The close cooperation between the top decision-makers of the state and the central labour market organisations in corporatist countries is a traditional example of policy networks (Pekkarinen, Pohjola, and Rowthorn 1992). However, today, policy networks can involve actors from many different levels and sectors of the society.

Conclusion

Systems of innovation may be regarded as a useful tool to support policy makers in their attempt to boost innovation and economic growth. The new rational of innovation policy, based on the recursive innovation concept, is to ask the more general question of where and how the performance of innovation systems is weak. All such systemic failures are potential targets for government intervention. Identification of systemic failures does not automatically need to involve the state in the innovation process. Only if state intervention provides the most efficient solution is the state legitimised to address a specific system failure and to provide tools to overcome the failure.

The new systemic perspective has inspired a new direction of innovation policy. We can speak about a new innovation enabling approach; an increasing emphasis has been given to industrial clusters and networks. Together with the introduction of the new approach, the role of the state in innovation policy has changed. In the frame of a conditions-enabling policy, the significance of technical macro-economic management may decrease, but the role of the state as a facilitator and orchestrator of private economic actors remains strong (Hirst and Thompson 1992).

The growing importance of cooperative networks has also been recognised by governments in recent years. They have developed many different types of policy measures to facilitate the creation and efficient functioning of inter-firm networks. However, these government interventions have not been based on a sound theoretical framework of the government role in network facilitation. Indeed, there is not yet a well-developed theory of network policy available.

In this chapter, we have presented some kind of ideal type of network policy, mentioning the different problems involved and the different stages of intervention. We have also given some examples of network-facilitating policies in Finland and in Europe. Due to the short history, it is not possible to identify the overall impact and success of the network-facilitating policy; we cannot identify a best practice yet.

We have argued in this chapter that public organisations have been challenged by the same dynamic factors as their private sector counterparts and that they also search for the best solution to coordinate increasingly specialised activities of the public sector. 'Quasi-markets' and 'public-private partnerships' are increasingly used in the provision of public services; we can speak of a new type of 'policy networks'. Such hybrid solutions require very skillful and difficult balancing of the features of different organisational alternatives. There is definitely a need to better understand the new role of governments in innovation policy and the mechanism of policy networks.

11 POLICY AND RESEARCH CHALLENGES

We began our study by arguing that industrialised countries are witnessing a major structural transformation process. The structural changes reflect the growing value of the production, diffusion, and use of knowledge. The OECD has consistently stressed the move towards a knowledge-based economy (OECD 1996). At the heart of this discussion is the recognition that *innovation* plays a substantial role in the evolution of the knowledge-based economy. Innovation, which results from the application of technical and other knowledge, has become the key competition criterion in the globalising economy.

In this report, we have used a wider definition of innovation which includes not only technical but also social innovations, such as organisational, institutional and service innovations. Throughout the whole report we have argued that the social dimension of technical change and social innovations are becoming increasingly important as they represent assets which can hardly be copied and which therefore contribute to sustainable competitiveness. We have particularly referred to organisational changes within and among companies, new knowledge-intensive services, changes in various support organisations, as well as innovations in the political system. We see a major problem of Finnish innovation policy in the strong technical orientation, while the social dimension of innovation has been given less attention. Our argument is that innovation policy needs to combine economic, technical, and social aspects. It also needs to focus more on possible negative feedback on the strengthening of the economy's innovation capacity.

Innovation is strongly related to firms' *transformative capacity* and their *organisational competence building processes*. Firms must adapt to the changing techno-economic environment to succeed in the global innovation competition. But companies do not innovate in isolation; they depend on complementary knowledge and resources of other firms and supporting organisations. The notion

of the knowledge society implies the increasing centrality of specialised knowledge to economic activities, as reflected in the growth of *knowledge-based industries and knowledge-intensive services*.

The international debate on innovation policy has centred round the concept of national innovation system (NIS) in recent years (OECD 1997, 1999). The growing popularity of this concept reflects the fact that *systemic innovation* is a major determinant of industrial dynamics and economic performance. The system concept attempts to capture the systemic and interdependent character of modern innovation processes and socio-economic development. All these changes represent major challenges to policy makers.

Policy challenges

In this final chapter, we will analyse the challenges of the emerging knowledge economy to the Finnish economy and policy makers. We will identify weaknesses in the national innovation system and will discuss new options for innovation policy. In the light of Sitra's research programme and our own study, we have identified the following major challenges to the Finnish innovation policy:

1. techno-organisational restructuring and competence-building at the firm level;
2. modernisation of low-tech industries;
3. development of knowledge-intensive business services;
4. supporting inter-organisational network formation;
5. strengthening basic research;
6. adapting the education system;
7. preventing social segmentation and social exclusion;
8. fostering inter-regional cooperation;
9. developing instruments to support policy-learning.

Techno-organisational restructuring and competence-building at the firm level

The traditional Fordist production model was developed for standardised mass production and includes many in-built mechanisms that tend to block innovation activities. Today, an increasing number of firms in a growing number of sectors will have to adopt new organisational arrangements in order to succeed in the global innovation competition. There is no doubt that the latest breakthroughs in ICTs have had a major impact on firms' restructuring strategies. However, restructuring involves far more than applying modern ICTs. In particular, we have

to emphasise a cluster of complementary *social innovations* including new organisation forms, flexible work regulations, new skills and competencies, inter-organisational cooperation and networking, as well as a trust-based organisation culture. The OECD (2000b) characterises the organisational forms that support innovation as *'high-performance work practices'.*

Despite Finland's overall competitiveness in the international patent statistics (see Appendix), according to CIS data (Foyn 2000) Finnish manufacturing and service firms are on average *less innovative* than companies in the leading European countries. Particularly, the Finnish SMEs are lagging behind the European average. The more innovative large firms explain the good performance of Finland in international patent data. Industrial differences in innovativeness are also quite significant; while most companies in the telecommunications sector introduce new products or processes regularly, traditional industries are less innovative. The Finnish SMEs should be encouraged to *adopt a philosophy of continuous improvement and innovation*, particularly as the life cycles of products in many industries are decreasing quite drastically.

The fact that the number of *rapidly growing innovative SMEs* is comparatively low in Finland may have serious consequences in the future (see also Lemola 1999). Nowadays large companies, particularly in traditional industries, restructure their supplier chain on a global scale, reducing their partners to a small number of *system suppliers* with the capacity to *collaborate in joint innovation processes*. It would be important for the Finnish economy to have a larger number of system suppliers, as such firms organise their own supplier chains more locally and thereby create new jobs. The development of new system suppliers could be an explicit goal of the network-facilitating innovation policy.

Finnish firms are among the most advanced users of ICTs (e.g. computers, Internet, e-mail, EDI) in the world. However, the use of ICTs still seems to be dominated by traditional activities, such as information search, transmitting and receiving data files, and competitor analysis (Statistics Finland 1999). It would be important that particularly SMEs made more advanced use of modern ICT. The more traditional use of modern ICT may explain, why there is little evidence that the leading role of Finland in ICT production and the intensive use of modern ICT had led to a wide-spread productivity growth in the Finnish economy (OECD 2000f)[98].

As we have argued before, firms will have to *invest in complementary assets,* such as new organisation forms and new skills and competencies, in order to be able to reap the benefits of modern ICT. Alasoini (1999) stresses that Finnish companies may have assumed a leading position in Europe in terms of *intra-organisational restructuring*. The introduction of group work has progressed very rapidly in Finnish firms and they have also started to undertake more radical organisational innovations, such as cellular production. These are changes on the

[98] This reflects the well-known productivity paradox linked to ICT investments.

shop floor; their target is the production process. Those changes do not capture the whole picture of organisational restructuring. Global innovation competition demands a systemic restructuring strategy. Unfortunately, in Finland there is little information available about companies' organisational restructuring practices.

Finnish employers consider *staff training programmes* to be of very high quality. However, further education programmes in Finnish companies do not differ significantly from those in other European countries (Ministry of Finance 1998, 38). Companies report a *huge demand for various new skills and competencies*; in a firm survey, conducted in the Tampere region, three out of four companies mention the demand for international skills (76%), information processing skills (86%), multi-skilling (79%), and responsibility (75%). Case studies reveal that there is also a great demand for social skills and 'learning to learn competencies' (Schienstock et al. 2001). There is some evidence, however, that although the need for further training is widely admitted by companies, the great majority of them still develop the training programmes on an '*ad-hoc basis*' (Schienstock 1999). As skills upgrading becomes increasingly important in the knowledge economy, agreements of the social partners on *systematic and continuous further training* for all employees should become a key aspect in collective bargaining processes.

The above findings indicate that a significant number of companies in Finland have adopted at least *some elements* of 'high-performance work practices'. However, the empirical basis for this conclusion is rather weak. It is important that organisational restructuring and human resources become a major focus in the Finnish innovation policy. While various institutions such as Tekes, the Academy of Finland, the Ministry of Trade and Industry, the Ministry of Labour, the Ministry of Education and Sitra deal with single aspects of business restructuring, a *holistic approach* aimed at fostering the development of 'high-performance work practices' seems to be missing. As Alasoini (1999) argues, a major weakness in Finnish innovation policy is the *institutional separation between workplace development activities and technology policy*.

Concerning the restructuring of firms, we have identified the following challenges:

- raising awareness among SMEs about the importance of innovation in the global knowledge economy;
- supporting holistic restructuring processes in firms, including advanced use of ICT, new organisation forms, human resources development, and trust-based organisation culture;
- developing further training for employees as a strategic element to improve competence-building and innovation activities;
- combining policies of organisational, technological and human resource development into a coherent strategy of organisational restructuring and development; and
- supporting absorptive capacity of SMEs to enable cooperation with polytechnics and universities.

Modernisation of low-tech industries

There is, however, *no static single model* of firm organisation and strategy, which automatically brings benefits and supports innovation. The argument that there is a general trend towards 'high-performance workplaces' may actually conceal increasing *diversity* in firms' restructuring strategies depending on the environment in which they are positioned. Innovation processes in so-called *low-tech industries* differ significantly from those in high-tech industries and, therefore, different organisation models and business strategies are needed to boost innovations (Palmberg 2001). The restructuring strategies in low-tech industries include: continuous modernisation of production technology combined with social innovations in design, branding, marketing and after-sales services, flexibilisation of organisations, emphasis on vocational training, and close cooperation with customers and suppliers.

The specific situation of low-tech industries demands a more *tailor-made modernisation and innovation policy*. The fact that the *share of novel innovators* in traditional industries in Finland is comparatively low, according to CIS data, though companies have increased their R&D funding, seems to indicate that they still focus on the technical dimension of innovation and have greater problems *translating technological inventions into marketable products.* As low-tech companies obviously need more advice in designing and marketing their products, service supply in these fields should be developed.

Another important issue is related to the *integration of emerging new technologies* from the high-tech industries to the low-tech industries as a means to transform and renew existing areas of strength in these industries. This implies more intensive collaboration between the two sectors in innovation processes. Cooperation between high-tech and low-tech industries, however, is difficult to achieve due to different mental paradigms, heuristics, and thought worlds. Network-facilitating policy in Finland needs to give particular attention *to connecting industrial communities from high-tech and low-tech industries* around generic pre-paradigmatic technologies such as IT and software, new materials, or biotech (Palmberg 2001). In addition, the risks involved in the early stages of an emerging new technology should be mitigated through public action, since companies in low-tech industries seldom have resources for long-term development of their competencies and product technologies.

Tailor-made innovation policy for low-tech industries should also take into account the *broader framework conditions,* as companies in established industries are deeply embedded and dependent on their social and industrial context. In this respect, it is important to:

- pay attention to the secondary level of vocational training, as companies in low-tech industries depend on workers with practical engineering skills;
- focus competition legislation not only on controlling the development of market power but also on supporting innovation networks;

– support standardisation and consumer legislation also on the international level; and
– guarantee the sustainability of the specialised research infrastructure.

Development of knowledge-intensive business services

The recent discourse on innovation systems has focused more on the *role of services in the knowledge-based economy.* It is argued that while new products and processes will be copied sooner or later, services can guarantee *sustainable competitiveness* as they involve a lot of tacit knowledge. Many services are innovative in terms of generating new products; they are highly knowledge-intensive and heavy users of ICTs. Particularly technology-based KIBS firms have become important actors in the innovation system not only because they frequently innovate themselves but even more because they *play an important role in the diffusion of new knowledge and technologies* among their client firms. KIBS firms are important knowledge intermediaries in the innovation system and their contribution to their clients' innovation processes is significant.

In international comparison, the Finnish KIBS-sector does not seem to have exhausted its growth and employment potential (Leiponen 2001). With the exception of Internet-based and environment-based services, KIBS are less developed in Finland (OECD 1998a). On the other hand, there is a great demand for these business services. The lack of *marketing competencies* among Finnish SMEs, particularly in traditional low-tech industries, has been often emphasised. Also, *management competencies*, *organisational knowledge, and design competencies* seem to be rather weak among Finnish SMEs.

There is some evidence that some parts of the KIBS sector, including management and advertising companies are not well integrated into the national innovation system; particularly *cooperation with academic experts* seems to be rather weak. Having a key role in the knowledge diffusion processes, KIBS should be more closely integrated with the network-facilitating policies: otherwise the tacit knowledge created in these networks will not diffuse as efficiently as possible. In addition, research funding could be allocated to *joint projects among the academia, KIBS, and industrial clients.*

The lack of cooperation between parts of the KIBS sector and universities in R&D activities seems to be caused by the *low applicability of Finnish academic research in social sciences and in business schools* (Leiponen 2001). There is a need to strengthen *problem-oriented and applied research* in management, design, business organisation, and marketing. Acquiring *non-technical expertise* seems to cause some problems for KIBS firms. Although higher education institutions cannot always be expected to satisfy the special training needs of KIBS, one may ask whether the engineering-oriented higher education system in Finland (OECD 2000f) is well prepared for the knowledge-based service economy, where social innovations become increasingly important.

The concept of a *second knowledge infrastructure* implies that KIBS firms partly complement but also partly compete with the public knowledge infrastructure. It is important to identify those areas where KIBS firms can contribute more efficiently to knowledge creation and knowledge diffusion processes than public institutions, and to strengthen their role in these areas. But it is equally important to *support cooperation between private and public knowledge-diffusing organisations,* as boundaries between public and private knowledge-intensive services tend to blur gradually. There is a need to experiment with new divisions of tasks between private and public KIBS organisations and firms and to develop *new national knowledge management systems* (den Hertog and Bilderbeck 2000).

There is a good reason to emphasise the development of the KIBS sector in Finland, as Finnish KIBS firms are generally small and often less competitive than their foreign counterparts. Finnish KIBS firms need to be supported in the development of *growth strategies* including systematic sourcing of knowledge, use of modern ICT, and the introduction of efficient organisation models and incentive systems. The problem of small size and lack of reputation can be overcome by *increased cooperation and network-building both nationally and internationally*. A crucial problem seems to be that the Finnish culture does not value services. Public policy needs to support the development of a *'service culture'* by emphasising its great value with respect to growth and job creation.

Despite the emphasis on innovative and knowledge-based services, many *other types of services* still appear to be relatively inactive in terms of innovation. This does not mean, however, that they are less relevant from an innovation perspective. They often carry out important social functions and the improvement of their productivity and quality through innovation can significantly contribute to the social welfare of a nation. While services represent by far the biggest part of the economy they are relatively poorly integrated into the national innovation system (with the exception of some parts of the KIBS sector). It is necessary that innovation policy pays more attention to the whole service sector.

Concerning the role of KIBS in processes of knowledge production and diffusion, the following challenges must be emphasised:

- supporting the development of KIBS in areas where existing demand is not satisfied (marketing, management, design, organisation);
- strengthening the role of KIBS firms in the Finnish economy and internationally by supporting their growth strategies, including the application of new ICT-based organisation forms, improved human resources management and inter-firm networking;
- supporting the development of research and training capacities in universities and polytechnics specialised in the service sector;
- supporting the cooperation between private and public KIBS providers and strengthening the role of private KIBS firms in cooperative networks; and
- creating a more service-oriented culture in Finland.

Supporting inter-organisational network formation

In a globalising economy, firms have to specialise to compete successfully with foreign companies. Hence, they have become increasingly dependent on the complementary knowledge and resources of other firms and support institutions. At the same time, the development of new innovations increasingly requires the combination of knowledge and resources from different sources. It is therefore quite rare for firms to innovate in total isolation; new products, services and processes are increasingly developed collectively by a network of firms and various support institutions. With the emergence of collaborative innovation, innovation policy has to focus more on *supporting innovative networks than single innovative firms*.

A new survey of Finnish industrial firms shows that 71 percent of them participate in inter-organisational networks (TT 2001). The nature of cooperative relationships has also become deeper and more strategic during the past decade. Networking is most intensive in metal and electronics industries (88% of firms networking) and least intensive in forest (54%) and chemical (46%) industries. Moreover, the EU innovation survey (CIS) shows *that innovative firms* in Finland cooperate much more intensively with other firms and support institutions than companies in other European countries. Also, networking firms have obviously been more innovative and productive than firms that did not engage in inter-organisational cooperation and networking.

Finland seems to have more experience with the new network-facilitation policy than most other countries. Still there is some potential for further development:

- use the knowledge and resources of local and sectoral organisations to find out and reach the potential network partners;
- put more emphasis on cooperation and network formation between low-tech and high-tech industries;
- include KIBS firms more often in the process of network formation;
- use the network approach to develop service innovations;
- pursue a holistic approach to network development including technical, organisational and training aspects;
- support the development of system suppliers; and
- evaluate network projects and intensify dissemination activities.

Strengthening basic research in universities

Most European countries have shifted financial resources from basic towards more application-oriented funding during the 1990s. Some critical scholars argue, however, that this restructuring trend in Europe underestimates the *value of basic*

research (Pavitt 2000). Finland is one of the few exceptions where funding for basic research has still increased, though less than for applied research. There is good reason for further strengthening of basic research. First, due to the fact that the process of technological development has become more complex and less controllable, it becomes increasingly difficult to plan concrete applications of basic research. Second, unexpected scientific discoveries and technological opportunities often satisfy the existing demand. Also, the Finnish industry seems to support a strong emphasis on basic research funding (Nieminen and Kaukonen 2001).

During the last years *competitive programme-based funding* has been introduced to increase the effectiveness and efficiency of the S&T system. Together with other measures, such as promoting networks and collaboration between universities and companies, it has contributed to the fact that *science-industry cooperation* is quite active in Finland compared to other industrialised countries. This approach may also have accelerated necessary structural changes within universities, which otherwise might not have taken place.

Finland has also been very successful in developing international research cooperation. Finnish researchers participate in many European projects and programmes. It might be necessary, however, to strengthen research cooperation with partners from the USA and Japan, as these are the leading countries in many fields of scientific and technological development.

In addition, while recent discussions have mainly focused on the research function, less attention has been given to *teaching* as the 'academic core'. It is important to stress that the teaching function contributes significantly to the efficiency of innovation systems, as firms' capacity to tackle new problems requires new skills, competencies, and knowledge. Therefore, and not least from an innovation perspective, it is important that university-related public policy takes into account the multiple functions of universities. As there is no one best model, policy should encourage and support *organisational experiments* within universities aiming at combining the various functions in an efficient way. Incentives should be geared to *fostering interdisciplinary research and teaching activities*. And as technical and social innovations are increasingly intertwined, particular emphasis should be given to the *cooperation between technical disciplines and social sciences.*

Above we have mentioned the increasing importance of KIBS (knowledge-intensive business services) firms in the innovation systems taking up a bridging function between more and more specialised firms. There is a need for universities to create a *research and teaching infrastructure* that could support the development and growth of the KIBS sector and foster innovations in all service sectors. Particularly *social sciences,* including economics, are challenged to develop the needed knowledge base and to provide teaching programmes that could increase competencies in the (knowledge-intensive business) service sector. The creation of *research and teaching centres* in this field should be supported.

With respect to the university system, we have identified the following major problems:

- further developing of a high-quality science base, as developing high-tech industries increasingly depends on new scientific knowledge;
- guaranteeing high-quality teaching, as a well-trained workforce and highly qualified scientists become increasingly important to companies' capability to continuously innovate;
- encouraging and supporting organisational experiments within universities aiming at combining the teaching and research function in a more efficient way; and
- encouraging and stimulating research and training activities in the field of services to broaden the knowledge base for (knowledge-intensive) service firms in Finland.

Adapting the education system

The main characteristic of the knowledge economy is not the rapidly growing knowledge stock but the *acceleration of both knowledge creation and knowledge destruction*. This is reflected in *new skill demands*; the fundamental requirement is that employees have the capacity to absorb new knowledge and to combine different pieces of existing knowledge in a new way. This type of competence is characterised as *'learning-to-learn capability'* (Lundvall and Borrás 1997) or as *'dynamic expertise'* (Hakkarainen et al. 2001). The capability to learn how to learn becomes very important in the knowledge economy where employees have to continuously renew their knowledge.

The changing skills and competence needs demand some changes in education and training institutions (Hakkarainen et al. 2001). It is important that students are more involved with *solving such kind of complex and authentic problems,* experts have to solve in working life. This means that they should not only be engaged in exploitation of knowledge but should also participate in processes of knowledge exploration to develop the 'learning-to-learn capability' or 'dynamic competence'. These skills should be taught more often *in the education system* by increasing the research-like aspects in teaching (Hakkarainen et al. 2001, 224).

The problem-oriented approach implies that work and training have to be more integrated. More of the training and learning has to take place at the workplace or in close connection with firms; firms have to become important learning places. Then training issues become more closely linked with companies' restructuring processes. This suggests that, in a knowledge economy, education and learning need to be given high priority in collective bargaining processes. One of the main goals of the new ICT-intensive organisations should be to increase the learning opportunities of their employees. What is needed is a diversity of learning places that have *different focal points but are closely interconnected* with each other.

It is also important to critically analyse the *education system in terms of inclusion and exclusion*, as youth employment in Finland is comparatively high.

One might argue that the attempt to carry all students through the three levels of the education system in a standardised way, motivated by the aim of equality may actually produce social exclusion. An *inclusive education* is needed, which is based on a more diverse and flexible curriculum taking into account the human diversity with respect to skills, competencies, learning capacities, and motivations. Such an inclusive education system becomes more and more important, as in the near future, due to a *decreasing younger population,* it will become increasingly difficult to find sufficient numbers of qualified students to enrol in those academic and vocational study programmes that are crucial for technical and other innovations.

It has often been stressed that in the knowledge economy, we cannot rely on one vocation only in the knowledge economy. In Finland, an increasing number of people are prepared for being trained in a second vocation during their working career. The Finnish education system, however, is *based on a sequential model*; more than half of an age group is studying up to the age of 25, only to realise that their knowledge soon becomes outdated and that they need to be retrained. It is necessary to base the education system on a new model which allows the *alternation of work and training phases*, taking the need for lifelong learning seriously.

The introduction of polytechnics is the *biggest reform* in the Finnish education system since the introduction of the comprehensive school in the 1970s. The main goal of the reform was to raise the standard of higher vocational education, creating a non-university sector at par with the university system. The polytechnic reform can be seen as an important policy measure to support the transformation of the Finnish economy into a knowledge economy. It was an important response to the changing and increasing skill requirements of Finnish firms.

However, some polytechnics seem to have problems in defining their new role in the dual higher education system. For example, only few politechnics have built up research capacity; many polytechnics, however, do not have the competence to engage in research activities. To sharpen the role of politechnics there is a need to support the developed of their research competence.

There is also the need to encourage *specialisation processes within the sector of polytechnics* according to the specific demands of regional economies or industries. Today, most of the polytechnics provide general standard programmes in small units which leave little resources for more specialised programmes. *Network formation among polytechnics* could push the process of specialisation ahead.

In the following, we will enumerate some major challenges to the Finnish education system:

- change toward inclusive education with attention to the special needs of particular student groups;
- development of workplace learning and integration of diverse learning places;
- moving towards problem-oriented learning and development of students' 'learning-to-learn capability';
- transforming the sequential education model into a more flexible model that

facilitates the transition from work to education and back;
- enhancing teachers' professional development by creating networks that support collaboration and knowledge exchange among teachers;
- giving high priority to education and learning in collective bargaining processes;
- strengthening the research capacity of polytechnics;
- encouraging polytechnics to specialise according to regional and sectoral needs;
- supporting network formation among polytechnics to compensate for the small size of many institutions; and
- supporting the developed of research competence in polytechnics.

Preventing social segmentation and social exclusion

The fact that innovations do not only produce social benefits but also *social costs* implies that innovation policy has to take into account problems related to the unequal distribution of such costs. Phases of rapid transformation produce more employment problems than phases of economic stability and, therefore, pose greater challenges to policy makers. *Social cohesion* is crucial for the knowledge society as uneven distribution of the costs and benefits of change may undermine the economic success of the transformation process in the long run.

In Finland, structural unemployment has become a problem to social cohesion because it destroys *social capital*. The unemployment rate in this country is still comparatively high, although it has decreased significantly during the past few years. It is about double the average of the best-performing countries in the OECD. Furthermore, the long-term, structural unemployment forms a substantial part of total unemployment. Youth unemployment is also high compared with the situation in most other European countries (OECD 2000f). While highly qualified people have very good chances of moving to better jobs, low-skilled employees are at risk of being pushed to the periphery of the labour market with highly insecure jobs or even becoming unemployed and *socially excluded*.

It is important to become aware of the *unbalanced distribution of costs and benefits* of the rapid transformation process and to analyse carefully the employment problems associated with an active innovation policy. While the knowledge-intensive growth strategy and increasing R&D expenditures in general have positive employment effects, the integration of unskilled people and slow learners may require more tailor-made policy measures. Some scholars have warned about the risk of *increasing segmentation problems* in a knowledge-based economy.

In order to avoid social segmentation and exclusion, '*proactive competence developing*' policies need to get a high priority in Finland. Such policies do no longer focus on compensation for resource deficits but concentrate on the strengthening of individual competencies to support a more *active career planning and organisation* (Schmidt 1996). An obvious educational challenge of the

knowledge economy is to enable all citizens to use modern ICTs in an effective and intelligent way. Furthermore, employees need to be prepared to cope with the increasing uncertainty and insecurity during their working career. Having learnt one profession at the beginning of the work career does no longer guarantee stable employment throughout the whole working life (Suikkanen et al. 2001).

Despite these challenges, the Finnish educational system and occupational structures are still based on a strong *sense of identity and stability;* they do not prepare employees to deal with changing situations and skills demands (Hakkarainen et al 2001). It is a great challenge to the education system to foster occupational and geographical mobility and to make employees aware of the need of becoming *an active planner and organiser of their working life careers*.

More *tailor-made training programmes*, taking the *specific risk situation* of employees into account, may help in dealing with the unemployment problem. Risk groups facing unemployment should be trained to overcome the mismatch between needed and existing skills and competencies, unemployed and particularly long-term unemployed should be given the opportunity to gain multi-layered vocational education.

It is often argued that in the knowledge-based economy, *employment needs to become more flexible* (Schmidt 1996). The spread of *atypical employment relationships*, such as part-time work, could probably reduce the unemployment rate in Finland whose labour market is predominantly based on full-time jobs (OECD 2000f). The Netherlands represents an interesting example in this respect. It is important, however, to *avoid any discrimination* of employees with atypical employment contracts. Furthermore, the introduction of so-called '*transitory labour markets'* with less standardised employment (allowing a more flexible transition from and into work) may be a promising strategy as well. Such labour markets allow more *variability in a stable employment.*

The following social innovations may help to distribute the costs and benefits in the knowledge economy more equally and to reduce unemployment:

- focusing on a 'proactive competence developing' policy instead of compensation-based social policy;
- enabling and encouraging more mobility between occupations, firms, and territories;
- preparing employees to cope with increasing uncertainty and insecurity in working life;
- offering more tailor-made training programmes, taking the specific risk situation of employees into account;
- establishing further training as a fourth pillar in the education system;
- admitting more atypical and flexible employment and enhancing the social security of flexi-workers; and
- making transition from and into work easier through flexible work regulations.

Strengthening regional innovation policy

In the innovation literature, the rationale for innovation policy, which focuses on the establishment of national framework conditions, has recently been questioned as the required policy support often differs from firm to firm. Innovation policy, it is argued, should focus more on *industrial clusters and regional agglomerations.* The Finnish cluster programme represents an innovative experiment in innovation policy, as it recognises the need for a more sector oriented innovation policy (see Prihti et al. 2000). With respect to regional innovation policy in Finland, we have to take into account that regions differ significantly according to their size. The German region Baden-Württemberg, for example, has about twice as many inhabitants as Finland. We therefore have to be careful in applying findings from the debate on regional systems of innovation to the Finnish situation.

The Finnish innovation policy has also recently focused on the regional dimension. However, as Lemola (1999) argues, the development of Finnish regional innovation policy is not based on rational decision-making, it is mainly motivated by the regional policy of the EU. The Centres of Expertise Programme, and the recent polytechnic reform underline the *new regional orientation* of Finnish innovation policy. Also the establishment of the new T&E Centres can be seen as an attempt to make regional policy more effective. Developing regional innovation systems in Finland, however, poses some problems. In a small country like Finland, a strong focus on regional development and networking among local companies might prevent more efficient cooperation among firms located in different regions (Miettinen 2001).

Furthermore, regional competition, stimulated through the Centres of Expertise Programme, might lead to the parallel establishment *of highly overlapping institutional settings.* There are, for example, 51 higher education institutions in Finland for five million people with a young age group of sixty thousand people. One can doubt whether this *pronounced regionalism* in the field of higher education with small units is a very effective way to organise industrial networks (Raivola et al. 2001). To give another example, there are six centres of expertise in the field of biotechnology in Finland. While the establishment of competing centres of expertise in a newly developing field may stimulate knowledge creation through competition, one can still ask whether such regionalism allows for the development of a critical mass to organise knowledge creation efficiently.

While examples like Emilia-Romagna and Silicon Valley support the argument that a strong focus on regional innovation systems can stimulate economic growth, such a strategy can be questioned in the case of Finland. It would at least be very important to put emphasis on *inter-regional cooperation.* Incentives are necessary to initiate the *sharing of support institutions* and to stimulate trans-regional networking among support organisations such as polytechnics, universities and research institutes. In addition, the formation of *regional partnerships* could increase

the leverage of innovation policy to those regions that are not involved in the knowledge-intensive growth. In addition, the cooperation between the national and the regional level in developing a regional innovation policy needs to be improved.

Regional innovation policy in Finland should take the following aspects into account:

- sharing support institutions among regions to guarantee critical mass;
- supporting inter-regional cooperation;
- developing inter-regional partnerships
- defining more clearly division of tasks between national and regional actors in the innovation process; and
- improving the cooperation between actors of the regional and the national system of innovation.

Policy coordination and policy learning

There is not only a need to rethink specific policies related to business restructuring, education, social affairs, or other issues, it is even more important to *combine these specialised policies into holistic and coherent policy strategies* (Lundvall and Archibugi 2001). Particularly in a period of fundamental transformation, mutual adjustment of various policy areas is crucially important. Science and technology policy, labour market and social policy, education policy, environmental policy, industrial policy and others have to be linked to foster *systemic transformation as well as to create and sustain systemic advantages.* The cross-sectoral coordination of public policies and government activities is still problematic in Finland (Bouckeart, Ormond and Peters 2000; VTV 2001). In the more competitive environment more emphasis needs to be put on those government activities that directly support economic efficiency, competitiveness, and growth, and hence create a sustainable basis for the social equity oriented government expenditures.

Innovation policy has to take into account the *ecological and social aspects* in particular. There is, as we have argued earlier, a risk that the emerging knowledge economy will produce social segmentation and exclusion. Growth strategies may undermine social capital and welfare by widening the gap between information rich and information poor, between skilled and unskilled people, and between slow learners and quick learners.

The interdependence of various policy fields creates a major challenge to policy makers. They have to develop measures to coordinate and re-integrate the separate perspectives and aims of related policies more effectively. In Finland, the development of a general framework for innovation policy seems to function well. The *vision* of a Knowledge Society introduced by the Science and Technology Policy Council does not only integrate the various views of policy makers but also those of other key economic actors. Unfortunately, the implementation of the

vision in the separate strategies of the various Ministries and government agencies is not always very well coordinated. New horizontal coordination mechanisms are clearly needed.

Systemic policy development and policy learning could be supported by various mechanisms such as *evaluation studies, technology assessment, technological foresight, and structural competitiveness benchmarking* (Lundvall and Borrás 1997). Although an active evaluation culture has emerged in Finland (Oksanen 2000), particularly technology assessment, technological foresight, and competitiveness benchmarking are not systematically used as tools for policy learning, yet. Together they can be developed into a *monitoring system* that can help policy makers to react more quickly to the rapidly changing techno-economic environment and the new policy challenges emerging from the knowledge economy. Such a monitoring system could form the basis for a more strategic and future-oriented policy making process of the Finnish government.

The vision-oriented innovation policy must be complemented by horizontal policy coordination, which we have characterised as discursive coordination. This is a major challenge for the Finnish government where hierarchical coordination mechanisms seem to dominate (Brouckaert, Ormond and Peters 2000): Hierarchical coordination makes a coherent and concurrent transformation of the general policy outlines rather difficult. Direct horizontal communication and coordination between interdependent policy makers needs to be strengthened in order to make programmes of various institutions more coherent.

Finnish innovation policy seems to be dominated by a strong technical orientation. Researchers, however, point to the growing importance of social innovations and stress in particular the importance of an innovative knowledge-intensive service sector. Social, institutional and systemic innovations become increasingly the basis of sustainable competitive advantage. The following challenges to policy-making have been identified:

- adding the mechanism of discursive, horizontal coordination to the vision-oriented innovation policy;
- combining the specialised policies into a holistic and coherent innovation policy;
- supporting policy-learning by establishing technology assessment, technological foresight and competitiveness benchmarking activities; and
- putting more emphasis on the social dimension of innovation.

Research challenges

During the last ten years, the system approach has established itself as a useful concept to analyse innovation processes from a broader perspective. However, it is

still associated with various kinds of ambiguities. The system concept is not an uncontested and homogeneous one; different concepts and perspectives are still competing with each other (OECD 1998a). While Edquist sees the conceptual ambiguity as a strength in providing openness and flexibility that give room for competing perspectives and solutions, other authors criticise the poor ability of the system concept to function as a focusing device (Hauknes 2000). No common research agenda has yet been established that would allow cumulative knowledge creation in this field; research is still rather eclectic.

In addition, the system approach has so far not developed into a *formal theory*. There is, as McKelvey (1991) argues, not one adequate theory for innovation systems. Other authors have also stressed that there is a strong need for a more systematic theoretical underpinning of the innovation system concept (Lundvall 1998, Freeman and Soete 1997). The evolutionary framework can be seen as a useful starting point, but what exists so far can at best be characterised as a *conceptual framework.* The concept includes some factors relevant to innovation processes and points to some possible relationships, but a system of empirically testable hypotheses has not been developed, yet.[99] Consequently, most of the research applying the system concept is rather *descriptive*: it may allow some comparative analysis, but the theoretical status of the approach is still very weak. There is a need to go beyond the development of conceptual frameworks and to *strengthen the scientific basis of the concept* (Edquist 1997; see also Allardt 1994).

In addition, new *theoretical concepts* have emerged, challenging the traditional innovation system approach and focusing more on *innovation activities and processes* instead of institutional aspects. Theoretical concepts such as 'social practices' or 'actor network theory' have been used to study the transformation of social relationships and 'organisational learning' in innovation processes (Hakkarainen et al. 2001; Miettinen 2001; Tuomi 2001). This has broadened the scope of themes covered by the system approach, but it has on the other hand also contributed to strengthening of the scientific basis.

From the scientific perspective, the task of *developing a more formal, rigorous and coherent approach* is very challenging. So far, only few Finnish researchers have contributed to the international scientific debate. Compared to other Nordic countries, for example, the Finnish contribution to the development of the innovation systems approach is less visible. While Finland was the first country to apply the system approach as a basis for science and technology policy, a research community and an interdisciplinary discourse on innovation systems have not developed in this country[100].

This can be explained by the fact that the institutional basis for interdisciplinary research and teaching on innovation in Finland is rather small. The Sitra programme

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[99] For an intensive discussion of the scientific status of the system approach in general, see Parsons (1960).

[100] There are of course some books dealing more systematically with the innovation system approach in Finland. See e.g. Vuori and Vuorinen (1994) or Schienstock and Kuusi (1999).

has opened up an interdisciplinary discourse among Finnish researchers dealing with innovation aspects. This discourse will continue in the new Research Programme for Active Technology Policy (ProACT, *Teknologian, elinkeinoelämän ja yhteiskunnan vuorovaikutuksen tutkimusohjelma*) of the Ministry of Trade and Industry and Tekes, and in the Finnish Post-Graduate School in Science and Technology Studies (*Tieteen ja teknologian tutkimuksen valtakunnallinen tutkijakoulu*) being set up by the Academy of Finland. Still it is important to improve the research and teaching capacity in this field and to involve more scholars from non-economic disciplines, in particular law, political science, administrative science, and sociology in the scientific discourse. Research and teaching need to become more *interdisciplinary*. It is important to improve the research and teaching capacity[101] to institutionalise an interdisciplinary discourse, to establish a *dialogue between science, on the one hand, and policy makers and industry* on the other, and to involve more *scientists in international research programmes on innovation issues.*

During the last years, the focal area of the innovation system approach has changed and new fields and topics have been included. First, research increasingly concentrates on the individual firm as the nexus of the innovation system where transformation of knowledge into innovation takes place. Firms' restructuring processes under conditions of global innovation competition, have become a key research area. Recent research has stressed the importance of a *systemic restructuring approach* to boost innovation activities including new organisational forms, an advanced use of modern ICTs, flexible regulatory practices, and skills and competencies.

We need to better understand why companies adapt differently to an increasingly uncertain environment in the knowledge economy. What are the key elements that support innovation and how can companies develop *integrated competence-building strategies*? What are the barriers and problems firms are facing when applying modern ICT and changing organisation structures? As firms rarely innovate in isolation, research also needs to cover the various forms of collaboration, cooperation, and network formation. What kinds of cooperation and network patterns are most effective in supporting innovation activities?

Firm-based innovation research has increased in Finland in recent years. However, research has not produced the *empirical material* needed to study general restructuring trends.[102] In some countries, researchers have started *to monitor companies' restructuring practices systematically and continuously,* to better understand their changing needs of support in the transformation process.[103] It would be important to establish such a *monitoring system focusing on companies' innovation activities and their restructuring practices* in Finland as well.

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[101] Britain gives a good example of how to proceed: university departments have been invited to apply for institutes with specific research and teaching profiles in the area of innovation research financed for a longer period of time.

[102] Research in Finland is too much focused on case studies and action research, on methods that produce interesting results but rarely allow generalisation. See, however, Palmberg (2001) and Leiponen (2001).

[103] See, for example, the DISKO project in Denmark.

Researchers have started to analyse the innovation system as part of the economic system and the wider society. They become more interested in the relationships between the innovation system and other economic and social subsystems such as the labour market, the science system, the law, the ecological system, the industrial relations system, and others. This new area opens up two research perspectives. One research strand deals with the question of how to *renew and rebuild the institutional system* to support companies in their restructuring processes. This system becomes increasingly fragile in a period of fundamental transformation. The other strand focuses on the distribution of the *social costs and benefits related to the improvement of the innovation system* and the rapid structural adjustment process.

Due to the fact that interdisciplinary research on innovation systems has not been well established in Finland, the capacity to analyse the innovation system as part of the economy and the wider society is still limited. The Sitra programme, with its particular focus on the relationships between the innovation system and other economic and social sub-systems, has opened up a wider research perspective. But much more research is needed to better understand the mutual interdependence between these systems. We need to analyse, for example, the relationship between intellectual capital and social capital; how does social cohesion and trust affect innovation activities?

Concerning competition law, for example, there is widespread agreement that *dynamic efficiency* considerations have to be taken seriously (Määttä 2001). However, there is little empirical evidence on how various regulations influence innovation activities. More generally, we can argue that there is a need for research, which analyses the influence of various legal regulations on innovation. Such kind of an *evaluative approach* would be very helpful in judging possible consequences of legal reforms.

It is widely agreed that university-industry relationships are an important factor that influences the outcome of innovation systems. Recent theoretical concepts stress the importance of cooperation between science, industry, and policy in the process of knowledge creation. It has been argued that, in order to adapt to this new mode of knowledge creation, universities have to implement new organisational models. While some scholars favour an entrepreneurial approach, others warn that there are negative consequences of such a model for basic science and the education function, which – in the long run – would also have a negative impact on innovation activities. This controversy suggests that university-related research needs to focus on problems of *organisational renewal, incentive mechanisms, and interdisciplinary cooperation*.

There is relatively little research on negative feedback on innovation activities. Clearly feedback research provides a rich area for future studies. There is now, for example, increasing awareness of the possibility that the innovation-driven knowledge-based economy may *negatively affect social sustainability*. Authors like Reich (1992) speak about segmentation tendencies and the development of a new underclass, while other scholars stress increasing social exclusion risks

(Schienstock 2001). Research has only recently given more attention to *unintended negative consequences of innovation policies* and started to analyse the labour market problems related to innovation. As flexible labour markets are often seen as a core element to support innovativeness within companies, it is important to analyse how social security and social inclusion can be guaranteed under these conditions.

Researchers have become aware of the fact that traditional views on services do not give an adequate grip on the role and significance of services in innovation systems. It is argued that the capacity of innovation systems to diffuse and transfer knowledge increasingly depends upon the development of a 'second knowledge infrastructure' being composed of private and public KIBS. Knowledge transfer and diffusion have traditionally received much less attention in Finland than knowledge creation activities. In this respect, it is important to guarantee the ability of the public knowledge infrastructure to distribute knowledge in an effective and efficient way and to analyse whether KIBS can compensate for the possible weaknesses (den Hertog and Bilderbeek 2000). Will the public knowledge infrastructures be replaced by the private knowledge structure? How should division of labour and cooperation be organised? In Finland, more research is needed to better understand the relationship between the public and private knowledge infrastructures.

But, more generally, there is little research on the *role of services in the knowledge-based economy* in Finland (Leiponen 2001). The Finnish service sector seems to be an under-researched sector. It is important to understand why many service sectors are still lagging behind in terms of innovation. What are the development problems experienced by the service industries? As the service sector is very broad and embraces many types of services, we also have to ask whether the results are valid across the whole service sector. There is a need to *systematically research the various aspects of innovation in the Finnish service sector.*

Research has increasingly focused on the *policy dimension*. Traditional science and technology policy based on the linear innovation model has been criticised for focusing only on the aspect of knowledge generation but ignoring more or less the aspect of knowledge diffusion. The Finnish innovation policy has also focused primarily on knowledge creation, though the Finnish system only creates a fraction of the world's knowledge. Conceptualising innovation as a highly ambiguous, non-linear, interactive and social process not only requires a new type of innovation policy but also new governance forms. New concepts such as 'vision orientation', 'discursive coordination', 'policy networks' and 'policy learning' have been introduced to characterise changes in innovation policy-making. The role of the government has been characterised as one of orchestrating different interests instead of controlling innovation processes in a bureaucratic way.

There is a need to direct research to these policy aspects. A systematic assessment of policy development, policy types, and the impact of government efforts to stimulate innovation is needed. The systematic assessment of innovation policy also needs to include the *territorial aspect*. While the importance of the regional

and trans-national dimension of innovation policy has been widely acknowledged, the questions of how to divide tasks to make innovation policy more efficient and how to co-ordinate regional, national and trans-national innovation policy still remain open.

Almost all the research aspects mentioned above can be subsumed under *the concept of governance.* Indeed, one can argue that together with the current transformation process towards a knowledge economy, the traditional governing mechanisms have become increasingly destabilised and new arrangements of economic governance have advanced. We have witnessed changes in the *forms and mechanisms of governance*, we have *observed shifts in the locations of governance*, and we have *perceived changes in the styles of governance* (van Kersberger and van Waarden 2001).

Most of the problems and questions analysed in innovation system research crystallise around the concept of governance. A new and important research aspect has emerged, concerned with a diversity of economic and social aspects: politics, the law, public administration, the economy, business firms, society at large and its spatial and temporal dimension. The problem and concept of governance has acquired an acknowledged and prominent although still contested status as a focal research topic. While the concept has attracted the interest of various disciplines, hardly any attempts have been made to co-ordinate and integrate various approaches and research activities (van Kerberger and van Waarden 2001).

'Shifts in governance' could be used as an umbrella concept to stimulate and integrate research in the field of innovation systems. A programme focusing on this topic could also intensify interdisciplinary research, it might allow for building bridges between various disciplines involved in the field. There is good reason to assume that the concept of governance can become a vehicle for comparison, interdisciplinary work and mutual theoretical inspiration.

In the following, we will provide some questions and issues for the agenda for socio-economic innovation research:

- From a theoretical perspective, it is important to develop a scientific basis for innovation system research. How can we develop a more systematic theory on innovation systems? What are the new areas and concepts that need to be adapted? How can we integrate new perspectives into a common framework?

- The system perspective suggests analysing the innovation system as part of the economy and the wider society. Specific emphasis should be given to the interaction between the innovation system and the labour market, the tax system, the education system, the legal system and the industrial relations system. What kind of institutional and organisational changes are needed to support innovation processes?

- Taking into account that innovations do not only produce benefits but also costs resulting in social segmentation and exclusion as well as in ecological

destruction, it is important to analyse how to design a sustainable innovation system. How can we avoid the destruction of natural and social capital that might result from a growth-oriented innovation policy?

– As services represent a major part of the economy, it is important to understand the role of this sector in the overall dynamics of innovation and economic growth. Particularly the role of KIBS firms in the process of knowledge creation and diffusion and the interaction with public knowledge institutions needs to be analysed.

– Innovation competition has forced companies to fundamentally restructure their production and innovation processes. Such a holistic approach includes the advanced use of ICT, the introduction of new organisation forms, improvement of the human capital, inter-firm networking, and developing a trust-based organisation culture. There is a need to better understand companies' restructuring processes and to identify the bottlenecks hindering the development of high productivity and innovative work practices.

– An important part of the transformation into a knowledge society is the modernisation of traditional industries. Of particular importance is the integration of new knowledge produced in high-tech industries into the existing knowledge stock. We need to know much more about the problems and difficulties related to these very difficult modernisation processes.

– Traditional policy patterns do not often function very well in the emerging knowledge economy. We need to better understand the policy implications of transformation processes. What will be the role of the government in the knowledge-based economy? What forms of governance are most efficient? What should be the focus of future innovation policy? How should we divide tasks between the regional, national, and European level of policy-making?

– Researchers in the field of innovation systems have become increasingly aware of the usefulness of the concept of governance to analyse problems in this field as it combines economic, political, social, and legal aspects. There is a need to focus research on the 'shifts in governance', including aspects such as the location of governance, mechanisms and forms of governance, and dimensions of governance.

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FACTOR 1. PRODUCTIVE RESOURCES

	Venture capital (1/4)				Human capital (1/4)		Sc. know	ICT-infrastructure (1/4)			Resource competitiveness	
Weights:	(1/16)	(1/16)	(1/16)	(1/16)	(1/8)	(1/8)	(1/4)	(1/12)	(1/12)	(1/12)		
Country	**Vent. cap. availabil.**	**Vent.cap. investm's**	**Vent. cap. allocation**	**Listed co's per pop.**	**Tertiary graduates**	**Exp. years of tert.ed.**	**Sc. Pub./ Popul.**	**Internet acc. costs**	**Main lines /100 inh.**	**Internet hosts/1000**	**Weighted average**	**Stand.**
Australia	-0,10			1,38	0,35	1,05	0,45	1,05	0,45	0,30	0,60	0,83
Austria	-1,06	-0,72	0,12	-0,69	-1,42	-0,51	-0,24	-2,23	-0,52	-0,10	-0,68	-0,98
Belgium	-0,06	-0,07	2,60	-0,49	0,33	-0,16	0,07	-2,11	-0,48	-0,35	-0,08	-0,13
Canada	0,53			3,66	1,96	0,35	0,39	1,36	0,69	0,75	1,14	1,59
Denmark	0,27	-0,72	0,82	0,68	0,32	-0,16	1,05	0,15	1,01	0,42	0,48	0,66
Finland	**1,26**	**0,22**	**0,82**	**0,00**	**0,84**	**2,26**	**0,94**	**1,48**	**-0,04**	**2,16**	**1,07**	**1,49**
France	-0,03	0,08	-0,70	-0,52	-0,23	0,18	-0,28	-0,78	0,21	-0,79	-0,26	-0,39
Germany	0,26	-0,21	0,08	-0,72	0,06	-0,86	-0,35	-0,60	0,29	-0,61	-0,30	-0,44
Greece	-0,22	-0,79	-0,08	-0,16	-0,84	-0,16	-1,17	-0,15	-0,23	-0,93	-0,61	-0,87
Ireland	0,75	-0,36	0,77	-0,34	-0,17	-0,34	-0,53	-1,21	-0,82	-0,66	-0,37	-0,54
Italy	-0,87	-0,28	-0,60	-1,01	-1,66	-0,34	-0,95	0,75	-0,95	-0,91	-0,75	-1,08
Japan	-1,63	-0,79	-0,58	-0,40	0,95		-0,86	0,27	-0,09	-0,64	-0,23	-0,34
Netherlands	1,50	1,23	-0,58	-0,32	0,20	-0,51	0,52	-0,30	0,59	0,14	0,24	0,32
New Zealand	-1,15			-0,04	0,49	0,70	0,47	0,54	-0,60	0,23	0,13	0,17
Norway	0,45			0,77	0,39	0,87	0,36	0,36	1,39	1,03	0,63	0,88
Portugal	-0,55	-0,57	0,28	-0,68	-1,60	-0,51	-1,44	-0,21	-1,25	-0,93	-0,92	-1,31
Spain	-0,77	-0,43	-0,83	-0,44	-0,33	0,35	-0,91	0,78	-1,01	-0,90	-0,47	-0,68
Sweden	1,03	-0,21	-0,91	0,05	0,66	-0,16	1,63	0,45	1,23	0,70	0,67	0,92
Switzerland	-0,59			0,18	0,06	-1,55	2,21	-0,51	1,29	-0,21	0,36	0,49
Turkey	-1,80			-1,00	-1,97	-2,24	-1,93	0,66	-2,61	-1,08	-1,61	-2,29
United Kingdom	0,83	3,18	-1,71	0,14	0,13	0,01	0,52	-0,66	0,08	-0,31	0,23	0,30
USA	1,95	0,44	0,50	-0,06	1,49	1,74	0,03	0,90	1,37	2,70	1,00	1,40
										Average	**0,01**	**0,00**
										St. Dev.	**0,71**	**1,00**

Original indicators and data sources:

Venture capital availability = Survey: Availability of venture capital for business development. WCY (2000).
Vent. cap. inv./GDP = Tot. venture capital investments as a % of GDP (* 10), 1998, Science, technology and innovation, Key Figures 2000, Eurostat.
Venture capital allocation = Share of venture capital investment that was allocated toward firms in "seed" or "start-up" stages, 1998, Science, technology and innovation, Key Figures 2000, Eurostat.
Listed co's per pop. = Listed domestic companies per one million of population, 1999, World Development Report (2000)
Tertiary graduates = Share of population aged 25-64 who have completed tertiary-level degrees. 1998. Source: OECD Education at a Glance (2000).
Expected years of tertiary education = Estimated average number of years in tertiary education for a 17-year-old, 1998. OECD Education at a Glance (2000).
Sc.pub./Pop. = Number of scientific publications per 10000 inhabitants, 1999. Source: Suomen tieteen tila ja taso (2000).
Internet access costs 98-99, OECD (2000)
Main lines in use per 100 inhabitants, 1999. (WCY 2000).
Internet hosts per 1000 people, 1999, WCY (2000)

FACTOR 2. TECHNOLOGY

Standardized values of indicators:

	R&D inputs (1/3)		Innovations (1/3)		ICT-diffusion (1/3)			Technological competitiveness	
Weights:	1/6	1/6	1/6	1/6	1/9	1/9	1/9		
Country	**R&D/GDP**	**R&D pers.**	**Innov. coeff.**	**TRIAD patents**	**Mobile ph./1000**	**Internet hosts**	**Computers/ 1000**	**Weighted average**	**Standardized**
Australia	-0,15	0,36	0,05		-0,04	0,26	0,97	0,18	0,28
Austria	-0,28	-0,55	-0,28	-0,40	0,80	-0,41	-0,09	-0,22	-0,26
Belgium	-0,24	-0,19	-0,52	0,25	-0,66	-0,36	-0,09	-0,24	-0,29
Canada	-0,26	0,11	-0,48		-1,37	0,77	0,85	-0,16	-0,18
Denmark	0,18	0,90	-0,24	0,09	0,75	0,38	0,86	0,38	0,54
Finland	**1,27**	**1,16**	**0,12**	**0,78**	**1,99**	**1,93**	**1,08**	**1,11**	**1,53**
France	0,50	0,63	-0,30	-0,02	-0,38	-0,78	-0,26	-0,02	0,00
Germany	0,59	0,65	0,27	0,90	-0,87	-0,61	-0,28	0,21	0,31
Greece	-1,51	-1,35		-1,02	-0,27	-0,93	-1,76	-1,14	-1,51
Ireland	-0,31	-0,39	-0,30	-1,17	-0,31	-0,75	-0,02	-0,48	-0,62
Italy	-0,80	-0,83		-0,90	0,86	-0,88	-0,79	-0,66	-0,86
Japan	1,27	1,41	4,08	2,01	-0,15	-0,63	-0,22	1,35	1,85
Netherlands	0,33	0,49	-0,40	0,51	0,16	0,18	0,32	0,23	0,34
New Zealand	-0,93	-0,64	0,05		-1,54	0,45	0,43	-0,32	-0,39
Norway	-0,14	0,70	-0,21		1,62	1,07	1,07	0,44	0,63
Portugal	-1,31	-1,15	-0,66	-1,36	0,52	-0,93	-1,42	-0,95	-1,25
Spain	-1,10	-0,96	-0,57	-1,36	-0,16	-0,85	-1,26	-0,92	-1,20
Sweden	2,34	1,56	0,13	1,36	1,36	0,60	1,10	1,24	1,70
Switzerland	1,07	1,42	-0,04		0,28	-0,04	0,37	0,47	0,66
Turkey	-1,54	-1,86	-0,67		-2,01	-1,07	-2,32	-1,39	-1,84
United Kingdom	0,03	-1,25	-0,14	-0,17	0,05	-0,24	0,16	-0,26	-0,32
USA	1,00	-0,23	0,10	0,51	-0,64	2,84	1,30	0,62	0,87
							Average	**-0,02**	**0,00**
							St. Dev.	**0,74**	**1,00**

Original indicators and data sources:

R&D/GDP = Total expenditure on R&D as a percentage of GDP, 1998, WCY (2000)
R&D personnel = Total R&D personnel per 1000 capita, Full time work equivalent, 1998, WCY (2000)
Innovativeness coefficient = resident patent applications / 10 000 pop., 1997, OECD MSTI-database
TRIAD patents = Number of patents granted per million of population in three patent offices: EPO, USPTO and JPO, 1998, Science, technology and innovation, Key Figures 2000, Eurostat.
Mobile phone subscribers per 1000 persons, 1999. WCY (2000)
Internet hosts per 1000 inhabitants, 1999. OECD (2001)
Computers per 1000 people, 1999, WCY (2000)

FACTOR 3. ORGANIZATIONAL ARRANGEMENTS

Standardized values of indicators:

	Allocative efficiency (1/4)			Technical efficiency (1/4)			Coord. efficiency (1/4)		Organizat. Adjustm. (1/4)		**Organizational competititiveness**	
Weights:	(1/12)	(1/12)	(1/12)	(1/12)	(1/12)	(1/12)	(1/8)	(1/8)	(1/8)	(1/8)		
Country	**Unem-ployment**	**Working hours**	**Female lab.force**	**Worker motivation**	**Pay & pro-ductivity**	**Local compet.**	**Urbani-zation**	**Process mgmt**	**Organiz. flexibility**	**Delegation of authority**	**Weighted average**	**Stand.**
Australia	-0,08	-0,33	0,20	-0,35	0,40	-0,22	0,81	0,15	1,02	0,34	0,26	0,44
Austria	0,89	-0,74	-0,57	0,80	0,40	0,38	-1,11	0,23	-0,45	-0,21	-0,10	-0,16
Belgium	-0,56	-0,65	-0,31	0,09	-1,06	0,08	1,96	0,08	-0,66	0,67	0,06	0,10
Canada	-0,18	0,40	0,96	0,23	0,76	0,38	0,04	0,23	0,18	0,56	0,34	0,59
Denmark	0,60	-1,07	0,96	0,90	0,40	0,38	0,81	0,82	0,60	1,56	0,65	1,12
Finland	**-0,98**	**-0,50**	**1,47**	**0,89**	**1,13**	**-0,82**	**-0,92**	**0,94**	**1,86**	**0,90**	**0,45**	**0,77**
France	-1,19	-0,62	0,71	-1,61	-0,51	0,68	-0,15	-0,13	-0,97	-0,77	-0,46	-0,80
Germany	-0,50	-0,99	-0,06	0,55	-0,33	1,59	1,00	0,89	-1,39	0,12	0,10	0,17
Greece		0,00	-1,08	-1,96	-1,43	-0,52	-1,59	-1,90	-0,55	-1,65	-1,13	-1,93
Ireland	0,19	-0,28	-2,10	0,37	-0,33	-0,52	-1,68	0,08	0,81	0,01	-0,32	-0,55
Italy	-1,19	0,05	-1,08	-1,57	-1,25	-1,12	-0,92	-1,89	-1,92	-1,54	-1,30	-2,22
Japan	0,82	0,47	-0,31	1,07	0,03	0,38	0,24	0,87	-1,50	-0,65	0,07	0,13
Netherlands	1,02	-0,80	-0,57	1,15	-0,88	1,28	1,19	0,89	1,34	0,79	0,63	1,07
New Zealand	0,05	0,55	0,71	0,05	0,95	-0,52	0,91	-0,04	0,60	0,34	0,38	0,64
Norway	1,14	-0,57	0,96	0,37	-0,70	-2,02	-0,15	-0,20	-0,76	0,79	-0,11	-0,19
Portugal	0,69	-0,08	0,45	-0,87	-0,88	-0,52	-1,30	-1,76	-0,55	-1,65	-0,76	-1,30
Spain	-2,82	-0,15	-1,34	-1,53	-0,33	1,28	0,04	-1,23	0,39	-1,10	-0,64	-1,10
Sweden	-0,12	0,07	1,47	1,00	-0,88	-1,72	0,62	1,14	0,08	1,45	0,40	0,68
Switzerland	1,07	0,39	-0,57	1,30	1,86	-0,22	-0,82	1,11	-0,13	0,45	0,40	0,68
Turkey		3,80	-1,34	-0,77	-0,70	-0,52	-0,24	-0,92	0,29	-1,54	-0,26	-0,45
United Kingdom	0,31	0,20	0,45	-0,38	1,49	0,38	1,19	-0,55	0,18	0,34	0,35	0,60
USA	0,83	0,85	0,96	0,26	1,86	1,89	0,04	1,19	1,54	0,79	1,00	1,71
										Average	**0,00**	**0,00**
										St. Dev.	**0,58**	**1,00**

Original indicators and data sources:

Unemployment = Standardized unemployment rates, percent of civilian labor force, 1998-99, OECD Economic Outlook 68, 2000.
Working hours, average number per year, 1998, WCY (2000).
Female share of labor force, 1999. World development Report (2000).
Worker motivation, survey, WCY (2000).
Pay & productivity = Extent to which pay is directly related to productivity, survey, GCR (2000)
Local competition = Intensity of local competition, survey, GCR (2000).
Urban population share, 1999. World Development Report (2000).
Process management = Emphasis on process management (quality, supply chain, etc.), survey, WCY (2000)
Organizational flexibility = Adaptiveness of companies and the government to changes in economic cycle, survey, WCY (2000).
Delegation of authority = Willingness to delegate to subordinates, survey, GCR (2000).

FACTOR 4. PRODUCT MARKET CHARACTERISTICS

	Standardized values of indicators:							**Product market competitiveness**	
	Demand sophistication (1/2)			Instl constraints (1/4 (1/4)					
Country	**Final consun**	**Customer sophistic.**	**Advert. expendit.**	**Indirect taxes**	**Product liability**	**Technol. cooperat.**		**Average**	**Standard.**
Australia	-0,12	0,93	0,08	0,96	0,73	-0,23		0,30	0,41
Austria	0,28	0,15	-0,24	-0,31	0,09	-0,27		-0,06	-0,08
Belgium	0,10	0,17	-0,63	-0,33	-0,78	0,24		-0,14	-0,18
Canada	-0,09	0,62	-0,47	0,72	0,65	0,69		0,35	0,47
Denmark	0,89	0,40	0,96	-1,53	0,87	0,35		0,38	0,51
Finland	**-0,17**	**0,45**	**1,03**	**-0,92**	**1,37**	**1,69**		**0,70**	**0,93**
France	0,06	0,40	-0,50	-0,30	-0,59	0,02		-0,11	-0,15
Germany	0,37	0,21	0,46	0,37	-0,42	0,90		0,39	0,53
Greece	-0,95	-2,28	-1,07	-0,69	-0,62	-1,61		-1,28	-1,72
Ireland	-0,14	0,33	-0,69	-1,02	1,01	0,24		-0,02	-0,03
Italy	-0,39	-0,67	-0,97	0,14	-1,31	-1,25		-0,80	-1,07
Japan	1,69	0,69	0,81	1,87	-0,93	0,74		0,83	1,12
Netherlands	-0,23	0,65	0,02	-0,13	0,94	1,16		0,46	0,62
New Zealand	-1,01	0,36	-0,03	-0,30	0,64	-0,10		-0,10	-0,13
Norway	0,23	0,09	0,53	-1,45	1,16	-0,13		0,07	0,10
Portugal	-1,21	-1,61	-1,09	-1,25	-0,91	-1,74		-1,36	-1,82
Spain	-1,01	-1,42	-0,86	0,38	-0,08	-1,08		-0,78	-1,04
Sweden	0,09	0,49	-0,07	-0,02	1,14	0,82		0,43	0,57
Switzerland	1,35	0,76	1,51	1,55	0,27	0,88		1,05	1,41
Turkey	-2,35	-2,29	-2,03	0,46	-0,31	-1,90		-1,57	-2,10
United Kingdom	0,43	0,28	1,00	-0,29	-0,19	-0,41		0,12	0,16
USA	2,19	1,27	2,25	2,07	-2,70	1,00		1,12	1,50
							Average	**0,00**	**0,00**
							St. Dev.	**0,75**	**1,00**

Original indicators and data sources:

Final consumption = Private final consumption expenditure per capita, in US$, 1999. WCY (2000).
Customer sophistication, survey, WCY (2000).
Advertising expenditure per capita USD, 1998, WCY (2000).
Indirect taxes = Taxes on goods and services as a percentage of GDP, 1998, WCY (2000)
Product liability = Appropriateness of product and service liability for the purposes of customer protection and product development, survey, WCY (2000).
Technological cooperation among companies, survey, WCY (2000).

FACTOR 5. INTERNATIONAL BUSINESS ACTIVITIES

	Standardized values of indicators:				International business competitiveness	
		FDI (1/3)	Intl. Trade	Techn. Transfer		
Weights:	(1/6)	(1/6)	(1/3)	(1/3)		
Country	**IFDI Stock**	**OFDI+IFDI /investm.**	**Trade / GDP**	**Depend. ratio**	**Weighted average**	**Standard.**
Australia	0,33	-0,74	-0,76	-0,34	-0,44	-0,62
Austria	-0,66	-0,62	0,51	-0,18	-0,10	-0,12
Belgium	2,31	1,07	1,97	0,01	1,22	1,90
Canada	0,08	0,05	0,26	-0,30	0,01	0,05
Denmark	-0,30	-0,31	-0,01	-0,12	-0,15	-0,18
Finland	**-0,56**	**1,90**	**-0,01**	**-0,23**	**0,14**	**0,26**
France	-0,64	-0,34	-0,53	-0,33	-0,45	-0,65
Germany	-0,78	-0,36	-0,39	-0,35	-0,44	-0,63
Greece	-0,25	-0,91	-1,06		-0,82	-1,21
Ireland	0,60	0,48	2,94	0,04	1,17	1,83
Italy	-0,81	-0,78	-0,57		-0,68	-1,00
Japan	-1,29	-0,90	-1,28	-0,36	-0,91	-1,34
Netherlands	1,50	1,75	1,33	-0,23	0,91	1,42
New Zealand	2,58	-0,64	-0,25	-0,28	0,15	0,27
Norway	-0,34	-0,59	0,00	-0,27	-0,24	-0,33
Portugal	-0,10	-0,51	0,06	4,20	1,32	2,05
Spain	-0,06	-0,44	-0,44	-0,21	-0,30	-0,41
Sweden	0,00	1,99	0,24	-0,28	0,32	0,53
Switzerland	0,23	0,06	0,14	-0,24	0,02	0,07
Turkey	-1,11	-0,90	-0,51	0,16	-0,45	-0,64
United Kingdom	0,05	0,66	-0,43	-0,34	-0,14	-0,17
USA	-0,77	-0,46	-1,23	-0,36	-0,73	-1,08
				Average	**-0,03**	**0,00**
				St. Dev.	**0,66**	**1,00**

Original indicators and data sources:
IFDI Stock = Inward FDI stock as a percentage of GDP, 1998. World Investment Report (2000), United Nations.
OFDI+IFDI / Investments = Inward and outward FDI flows as a percentage of gross fixed capital fomation, 1998, World Investment Report (2000).
Trade / GDP = (Exports + Imports)/ 2*GDP, 1998, WCY (2000)
Dependency ratio = Non-resident per resident patent applications, 1997, OECD MSTI-database.

FACTOR 6. INSTITUTIONAL FRAMEWORK

Standardized values of indicators:

		Tax system (1/3)			Regulatory framework (1/3)				
Weights:	(1/9)	(1/9)	(1/9)		(1/15)	(1/15)	(1/15)	(1/15)	(1/15)
Country	**Taxes / GDP**	**Income taxes**	**Corporate taxes**		**Justice**	**Bureau-cracy**	**Compet. laws**	**Security of per.&prop.**	**Lab. mkt flexibility**
Australia	1,21	0,69	-1,14		0,73	0,60	0,89	0,67	-0,09
Austria	-0,81	-0,92	1,01		0,72	-0,48	0,63	1,50	-0,55
Belgium	-1,12	-0,99	-0,22		-1,01	-0,88	0,45	-0,83	-1,12
Canada	0,20	0,41	-0,64		0,88	0,40	0,68	1,22	1,38
Denmark	-1,51	-1,53	0,49		0,95	1,07	0,67	0,85	1,50
Finland	**-1,16**	**-1,51**	**-1,01**		**0,84**	**1,75**	**1,34**	**1,26**	**0,13**
France	-0,92	-0,43	0,59		-0,45	-1,03	-0,42	-0,57	-0,78
Germany	0,24	0,11	1,75		0,64	-0,43	1,11	0,87	-1,23
Greece	0,72	0,56	0,18		-0,94	-1,45	-2,09	-1,37	-0,32
Ireland	0,20	1,66	-0,88		0,64	1,23	0,61	0,29	-0,43
Italy	-0,67	-0,88	-1,60		-2,02	-1,86	-1,19	-2,87	-1,12
Japan	1,49	1,13	0,97		-0,24	-0,74	-0,81	0,22	0,59
Netherlands	-0,36	-0,50	-1,14		0,85	1,14	1,28	-0,12	-0,32
New Zealand	0,55	0,28	-0,63		0,65	0,52	0,11	-0,47	-0,09
Norway	-0,69	-0,43	-1,00		0,64	0,33	1,02	0,47	-0,66
Portugal	0,26	0,77	-0,47		-1,98	-1,42	-1,05	-0,25	-0,43
Spain	0,68	1,64	0,82		-1,12	-0,29	-0,79	-0,22	-0,43
Sweden	-1,97	-1,54	0,19		0,62	0,93	0,10	-0,38	-1,34
Switzerland	0,55	1,24	1,26		0,65	1,02	-0,23	0,97	1,95
Turkey	1,35	-0,62	1,69		-1,66	-0,79	-2,04	-0,82	1,27
United Kingdom	0,22	0,22	-0,87		0,44	0,05	-0,01	-0,45	0,36
USA	1,53	0,67	0,63		0,17	0,35	-0,25	0,03	1,73

Original indicators and data sources:

Taxes / GDP = Total tax revenues as a percentage of GDP, 1998, WCY (2000).
Income taxes = Effective personal income tax rate as a percentage of GDP per capita, 1999, WCY (2000).
Corporate taxes = Collected corporate taxes on profits, income and capital gains as a percentage of GDP, 1998, WCY (2000).
Justice = How fairly is justice administereed in the country, survey, WCY (2000).
Bureaucracy = Extent to which bureaucracy hinders business development, survey, WCY (2000).
Competition laws do/ do not prevent unfair competition, survey, WCY (2000).
Security of person and property, survey, WCY (2000)
Labor market flexibility = Extent to which hiring and firing are determined by employers, survey, WCY (2000)

FACTOR 6. INSTITUTIONAL FRAMEWORK (cont.)

	Standardized values of indicators:			
	Studying incentives (1/3)		**Institutional competititiveness**	
Weights:	(1/6)	(1/6)		
Country	**Educat. & employm.**	**Educat. & earnings**	**Weightec average**	**Standardized**
Australia	0,72	-1,17	0,19	0,39
Austria	0,32		0,15	0,30
Belgium	0,88		-0,19	-0,37
Canada	0,24	-0,41	0,27	0,55
Denmark	-1,36	-0,97	-0,34	-0,65
Finland	**0,32**	**1,38**	**0,23**	**0,46**
France	-0,24	0,51	-0,26	-0,49
Germany	0,72	0,20	0,45	0,90
Greece	-1,44		-0,73	-1,42
Ireland	0,96	1,23	0,63	1,25
Italy	-0,88	-0,15	-1,13	-2,20
Japan	-0,24		0,25	0,51
Netherlands	-0,32	-1,12	-0,27	-0,53
New Zealand	-0,08	-0,56	-0,04	-0,06
Norway	-0,40	-1,07	-0,36	-0,70
Portugal	-0,56	1,68	-0,09	-0,17
Spain	-1,04	0,10	0,00	0,02
Sweden	-0,40	-1,53	-0,70	-1,36
Switzerland		0,15	0,68	1,35
Turkey	-1,28		-0,43	-0,83
United Kingdom	2,55	1,28	0,62	1,23
USA	1,51	1,28	0,91	1,81
		Average	**-0,01**	**0,00**
		St. Dev.	**0,51**	**1,00**

Original indicators and data sources:

Education & employment = Ratio of the unemployment rates of the below upper secondary level graduates and the tertiary level (type A, Ph.D.'s) graduates for men aged 25-64, 1998 (Austria, Finland, and Greece: 1997 data) OECD Education at a Glance (2000).
Education & earnings = earnings of people aged 25 - 64 with tertiary education (type A, Ph.D.'s) relative to the earnings of people with a base level of education (ISCED 3/4, OECD), 1997-98 (Finland and Netherlands 1996; Italy and Spain 1995), OECD (2000).

FACTOR 7. GOVERNMENT ROLE

Standardized values of indicators:

	Efficiency vs. Equity (4/5)				Adaptiveness		
	(1/5)	(1/5)	(1/5)	(1/5)	(1/5)	**Government competitiveness**	
Country	**Inc. transf. / GDP**	**Pub. Soc./ Tot. exp.**	**Pub.ed./ Tot. exp.**	**Pub. R&D/ / GDP**	**eGov. index**	**Average**	**Standard.**
Australia	1,82	0,48	0,81	-0,38	-0,14	0,52	1,15
Austria	-1,27	-0,11	-0,68	0,23	-0,06	-0,38	-0,67
Belgium	-0,07	0,82	-0,68	0,28	-1,19	-0,17	-0,24
Canada	1,02	2,24	0,52	-1,28	-0,86	0,33	0,76
Denmark	-0,93			0,68	1,52	0,42	0,96
Finland	**0,49**	**-0,30**	**0,18**	**2,38**	**-1,16**	**0,32**	**0,74**
France	-1,21	-0,86	-0,44	0,74	1,07	-0,14	-0,18
Germany	-1,37	-0,85	-1,06	0,83	1,22	-0,25	-0,40
Greece	-0,59			-1,56	-2,13	-1,43	-2,80
Ireland	1,39	0,15		-1,57	1,09	0,26	0,63
Italy	-0,96	-0,34	-1,30	-0,14	0,12	-0,53	-0,97
Japan	-0,47	1,85	-0,92	-0,06	-1,36	-0,19	-0,29
Netherlands	0,74	-0,25	-0,97	0,90	0,72	0,23	0,56
New Zealand		-0,65			-0,55	-0,60	-1,12
Norway	0,15	-0,98	1,91	0,73	1,22	0,60	1,33
Portugal	0,52			-0,23	0,42	0,24	0,58
Spain	0,55	0,33	-0,39	-0,97	0,43	-0,01	0,08
Sweden	-1,27	-0,32	0,18	0,80	-0,97	-0,32	-0,54
Switzerland		-1,80	1,72	0,42	0,23	0,14	0,38
Turkey					-0,61	-0,61	-1,15
United Kingdom	0,34	-0,35	-0,10	-0,86	0,06	-0,18	-0,28
USA	1,14	0,96	1,24	-0,94	0,95	0,67	1,46
					Average	**-0,05**	**0,00**
					St. Dev.	**0,49**	**1,00**

Original indicators and data sources:

Income transfers/ GDP 2000 = Income transfers (pensions, disability, sickness, family, unemployment and housing) as a percentage of the GDP (OECD 2001).
Public social expenditure / total public expenditure 1997 (Austria, Spain and Sweden 1996), OECD Social Expenditures 2000
Pub. Ed. / Tot. Exp. = Public educational expenditure as a percentage of total government expenditure, 1996, UNESCO statistics.
Pub. Civ. R&D / GDP = Total government expenditures on civilian R&D per GDP, 1998, OECD MSTI.
eGovernment index = percentage of ministries with web sites * (median ministry transparency score + median ministry interactivity score), 1998, Cyberspace Policy Research Group, NSF, Science & Engineering Indicators (2000)

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