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EU Innovation Policy: Analysis and Critique

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Summary: We analyze selected features of the innovation dynamics and innovation policy in the EU and the US. From a theoretical and empirical perspective specialization in high technology contributes to economic growth. The comparative analysis on Europe and the US suggests that the United States has achieved a considerable technological lead in the 1990s. As regards innovation dynamics in EU-25 it is shown that eastern European accession countries are far behind the EU-15 so that imitation processes and diffusion of innovations, respectively, play a crucial role in accession countries; in some of these countries there has been a considerable acceleration of Schumpeterian dynamics in the 1990s. The expansion of information and communication technology implies a greater significance of digital network effects – a mechanism that should be taken into account by policy makers. As regards policy perspectives we suggest some refinements in EU innovation policy which should be more focussed on market-relevant progress on the one hand and core fields of basic knowledge on the other hand while putting due emphasis on manageable projects.

Zusammenfassung: Untersucht werden einige ausgewählte Aspekte der Innovationsdynamik und der Innovationspolitik in der EU und den USA. Aus einer theoretischen und empirischen Sicht trägt die Spezialisierung auf Hochtechnologie in besonderem Maße zu Wirtschaftswachstum bei. Der Vergleich der Innovationsleistung in Europa und den USA zeigt ein Anwachsen des US-Technologievorsprungs in den 90er Jahren. Eine differenzierte Analyse der Innovationsdynamik in der EU-15 bzw. den osteuropäischen Beitrittsländern offenbart noch erhebliche Innovationsrückstände, die zugleich eine natürliche Konzentration auf Imitations- bzw. Diffusionsprozesse implizieren – bei allmählicher Schumpeterscher Innovationsbeschleunigung in einigen Ländern in den 90er Jahren. In den OECD-Ländern geht mit der Ausbreitung der Informations- und Kommunikationstechnologie eine verstärkte Bedeutung von digitalen Netzwerkeffekten einher, die auch innovationspolitisch wichtig sind. Der Beitrag schließt mit innovationspolitischen Reformvorschlägen, die darauf hinauslaufen, dass die EU stärker auf marktbezogene Forschungsprojekte und wenige Kernbereich der Grundlagenforschung ausgerichtet wird und zugleich auf kompakte Projekte achtet, die effizient managbar sind.

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1. Introduction

Economic globalization has accelerated the innovation race among leading OECD countries as foreign direct investment in Newly Industrializing Countries (NICs) plus China and India have created a new international divison of labor. Indeed, globalization went along with a more intensive innovation race (JUNGMITTAG/MEYER-KRAHMER/REGER, 1999). Moreover, in the 1990s increased R&D expenditures in China and many NICs as well as Russia have reinforced the ability of economic and technological catching-up. There is a certain minimum R&D expenditure requirement – relative to GDP – if countries are to be able to effectively adopt foreign technologies. Both innovation and fast diffusion can contribute critically to international innovativeness. Improving the international competitiveness of the overall EU-15 has been an explicit goal of the EU Lisbon summit of 2000. This summit has proclaimed the goal to make the EU the most competitive economy by 2010; exploitation of the digital information society is to play a crucial role in this respect as the Heads of State and Government of European Union endorsed the idea of a European Research Area (ERA) and declared the creation of a European knowledge-based society a crucial element of the political strategy.

With the expansion of digital networks and the internet, respectively, there are also new global channels for technology diffusion on the one hand, on the other hand modern digital networking also facilitates cooperation among researchers and engineers which enhances the effectiveness of the innovation process in leading OECD countries; this also applies to the EU-15 which has emphasized building a European Information Society early on (EUROPEAN COMMISSION, 2000).

The European Commission has considered some broad reforms in EU innovation policy in the document "Towards a European Research Area (ERA)" (EUROPEAN COMMISSION, 2000). The European Parliament has supported the project in a Resolution adopted on May 18, 2000. The new strategy accepts that national innovation policy is crucial but it seeks a well-defined complementary role of supranational innovation policy. Key elements of the new strategy are:

- better and more flexible co-ordination of national innovation policies;
- creating Networks of Excellence (NoE) which aim at reinforcing excellence on a research topic by creating large networks of R&D actors with a common focus on a joint programme of activities;
- establishing Integrated Projects (IP) which stand for multi-partner ventures which aim at bringing together a critical mass of resources to reach a specific research objective – with a strong focus on combining new knowledge for launching product innovations and process innovations.

According to the EU the Networks of Excellence and Integrated Projects, respectively, should reflect the following idea (Extract from the Decision No. 1513/002/Ec. of the European Parliament and of the Council of 27 June 2002 as quoted in CARACOSTAS, 2003, p.39):

"The purpose of Networks of Excellence is to strenghten and develop Community scientific and technological excellence by means of the integration, at European level, of research capacities currently existing or emerging at both national and regional level. Each Network will also aim at advancing knowledge in a particular area by assembling a critical mass of expertise. They will foster co-operation between

capacities of excellence in universities, research centers, enterprises, including SMEs, and science and technology organizations. The activities will be generally targeted towards long-term, multidisciplinary objectives, rather than predefined results in terms of products, processes or services…"

"Integrated Projects are designed to give increased impetus to the Community's competitiveness or to address major societal needs by mobilizing a critical mass of research and technological development resources and competencies. Each Integrated Project should be assigned clearly defined scientific and technological objectives and should be directed at obtaining specific results applicable in terms of, for instance, products, processes or services. (…) Subject to conditions to be specified in the specific programs and in the rules for participation, the Integrated Projects will have a high level of management autonomy including, where appropriate, the possibility to adapt the partnership and the content of the project. They will be carried out on the basis of overall financing plans preferably involving significant mobilization of public and private sector funding, including funding or collaboration schemes such as EUREKA, EIB and EIF."

Taking into account the principle of subsidiarity it is clear that EU R&D programmes must have extra EU-value-added, e.g. positive mutual – uniltaral or reciprocal - spillover effects in a joint innovation project.

To some extent the idea of creating networks of excellence certainly is adequate in the sense that in a single EU market there should be international R&D joint ventures organized within the framework of top R&D groups from several countries; this typically would bridge various national systems of innovations and also various languages in the Community. To some extent it also could bring useful cross-country R&D spillover effects, in particular for relatively backward countries which under different circumstances would find it more difficult to catch-up in terms of innovativeness. To the extent that successful R&D consortia applying for EU funds have integrated partners from EU countries with a relatively low per capita income – e.g. cohesion countries – one may anticipate accelerated diffusion of new technology in the community. It remains, however, an open question whether partners from low income countries can make considerable contributions to top R&D performance. Whether or not this is the case clearly will depend on stable networking and hence sufficient learning and cumulation effects. Establishing integrated projects also is a useful approach to the extent that university R&D (or similar external R&D centers) and R&D centers of firms cooperate smoothly.

In section 2 we take a closer look at major elements of EU innovation policy, while section 3 is a comparative analysis of key elements of innovation performance in OECD countries. Section 4 presents policy conclusions.

2. Innovation Policy in the EU

In the EU innovation policy is mainly a policy task faced at the national level. National innovation policies of EU member countries must take into account the "national innovation system" which is defined as the respective set of institutions, agencies and cultures relevant for the innovation process (LUNDVALL, 1992; HOLLINGSWORTH/BOYER, 1997). The EU has two elements of innovation policy at the level above national government (KUHLMANN/EDLER, 2003, p. 9/10):

- There are Framework Programmes (FP 1-FP 6) which aim at stimulating joint research efforts. The first FP of 1984 has emphasized industrial technologies, information technology, telecommunications and biotechnology. Subsequent framework programmes have broadened with respect to the scope of research topics and technologies.
- Outside the Framework Programmes the Commission has launched a range of regional innovation policy initiatives. E.g. in 1993 a special initiative termed Regional Technology Plans (RTP) was started, where the idea was to nurture regional innovation and growth in disadvantaged regions. Such pilot programmes can help to stimulate growth. The Commission is mainly playing a mentor role in RTP, the regions which finally were selected to enter with their projects the experimental stage are mainly responsible for the success of the respective programme.

In addition, there is transnational programmes such as COST and EUREKA. The latter, starting in 1985, includes not only the EU countries but countries from Eastern Europe and Russia as well. These programmes are intergovernmental initiatives which are mainly bottom-up programmes and emphasize international networking in R&D.

All this does not mean that the EU has a strong comprehensive innovation policy. Major problems in this respect refer to:

- Availability of rather limited funds at the level of the EU: Supranational funds have not reached more than roughly 4% of expenditures at the national level.
- Conflicting interests among high income countries with a high share of medium and high technology in manufacturing output as compared to low income countries with a high share of low and medium technology in manufacturing output. Low income countries anticipate that they will get a disproportionate share of EU R&D funds which implies considerable resistance against raising the relative share of supranational R&D expenditures in the overall EU budget. With EU eastern enlargement this problem might be reinforced.
- Problems in creating an integrated innovation system.

Despite all these problems one should not overlook the impact of the single market dynamics which include emergence of a large integrated capital market in the Euro area.

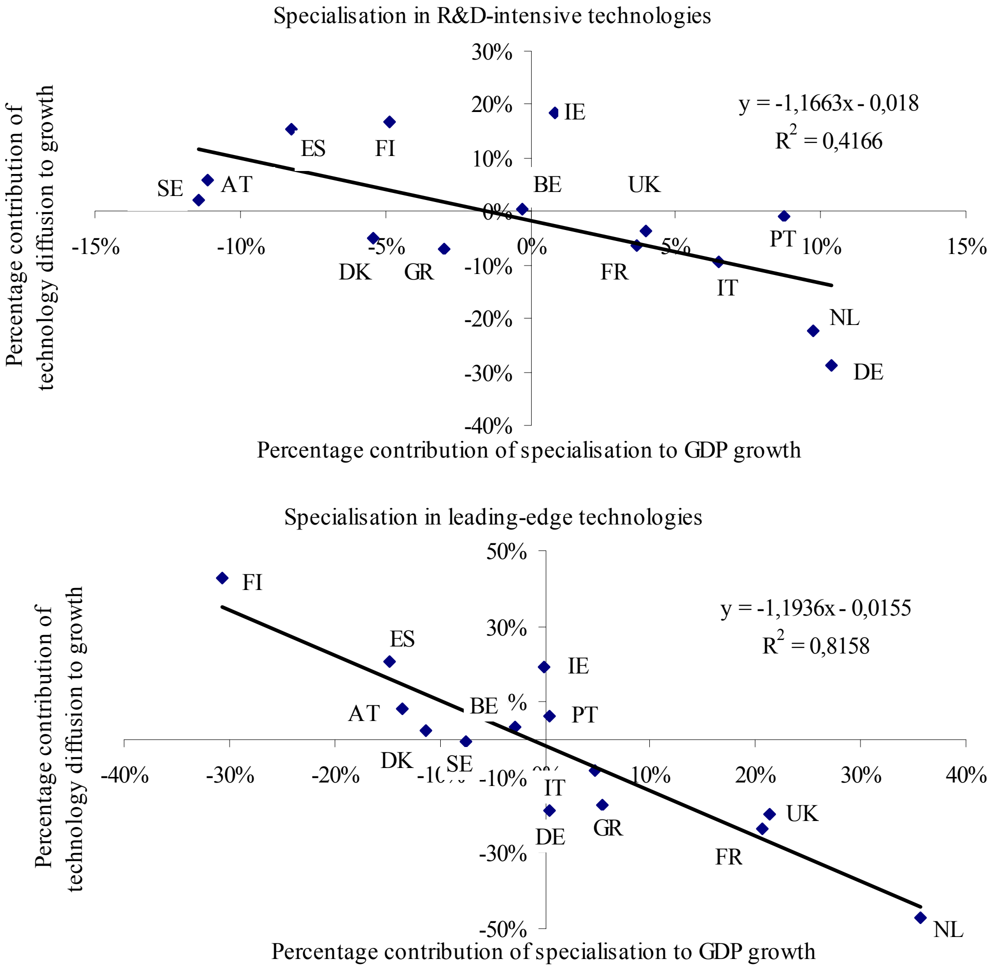
3. Innovation Dynamics in OECD Countries

3.1. Innovation, Specialization and Growth: Empirical Analysis for EU-15 and USA

Comparing economic development in the US and the EU and individual EU countries, respectively, there are various differences which might explain the relatively high dynamics of the US and the more modest growth in the EU in the 1990s. Superior US innovation dyanmics is only one aspect, a relatively high rate of population growth of the US is a second factor; and the growth of information and communication technology (ICT) is a third element where the US has benefitted both from increasing production of ICT goods and increasing use of ICT – based on the accumulation of ICT capital. It is well known that the expansion of ICT production has strongly contributed to technological progress in the US; it seems that most of the rise of total factor productivity in the 1990s indeed is attributable to ICT production (JORGENSEN, 2003). The issue of spillover effects and a more detailed analysis of total factor productivity growth thus remains on the agenda.

Taking a closer look at the EU requires to focus on individual countries and their respective catching-up and innovation dynamics. From an analytical perspective an augmented production function is useful in which capital, labor, technology and telecommunications play a role (WELFENS/JUNGMIITAG, 2002). Moreover, there is an additional growth bonus from specialization itself which can be divided into general specialization effects and high technology specializion effects. As regards technological catching-up dynamics within the EU there is clear empirical evidence that specilization effects matter, in particular in high technology (JUNGMITTAG, 2004). Moreover, there is evidence that some EU countries have made considerable progress in technological catching-up in the period 1970-95, this holds in particular for Finland and Ireland, but there is also some modest catching up of Spain. The following figure shows some of the relevant catching-up dynamics in the EU where we leave open to which extent diffusion, enhanced human capital formation and gross fixed capital formation plus innovation – strictly defined (and partly linked to foreign direct investment inflows) have contributed to convergence.

Fig. 1.: Correlations between contributions of transferable technical knowledge and technological specialisation to GDP growth



Source: Jungmittag (2004), Innovations, Technological Specialisation and Economic Growth in the EU, Brussels.

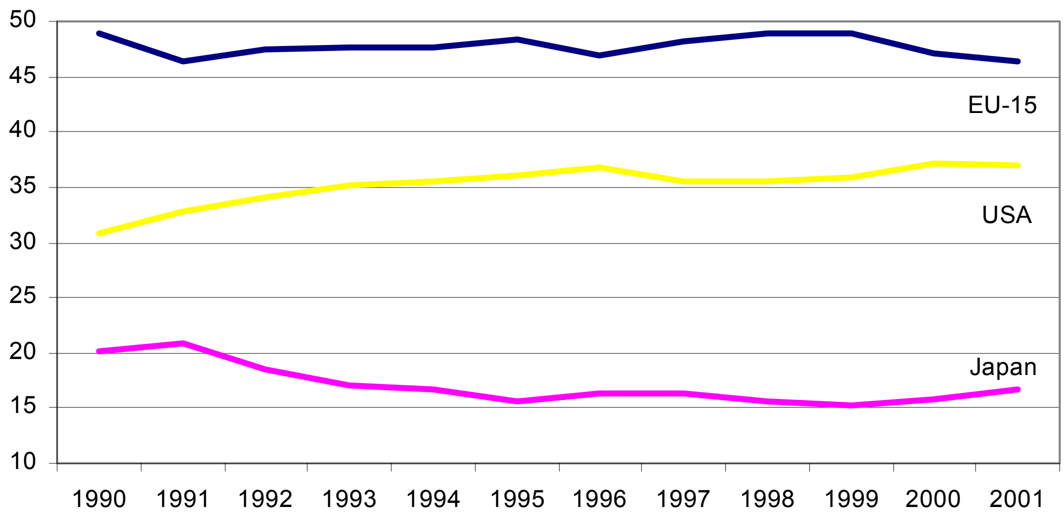
3.2. Comparative Innovation Dynamics

Innovation dynamics can be measured in various ways. There are two key figures to be considered crucially:

- As regards input in the R&D process one is interested in R&D expenditures relative to GDP or R&D expenditures per capita. If one is interested in a refined analysis one may take a look at expenditure figures on the basis of purchasing power parity which mainly reflects differences in the absolute price of nontradables across countries (e.g. construction prices in Spain are lower than in Germany or France or Scandinavia so that building a new research lab is relatively cheap in Spain – and other low income countries).
- As regards innovation output there is a natural interest in patent applications – and patents granted – on a per capita basis. Not all patents are equal so that there is particular interest in medium technology and high technology patents; and in those patent classes which show the highest growth rate. High growth rates reflect strong innovation dynamics. Not all innovations can, of course, be patented; in the case of innovative services and software trade marks and copyrights are important to some extent; alternatively, one might want to take a look at the share of new products in overall sales. As regards patenting one might have to consider two special problems: There seems to be an international tendency of leading firms to generally seek more patents where patent applications to some extent are used as a strategic means to deter rivals in the innovation race. In some high technology fields patenting might not be attractive as innovation cycles are so short that patenting does not give effective protection. Finally, there can be a rise in patent applications due to the fact that one patent at time t goes along with more "follower patents" in t+1 than in previous periods.

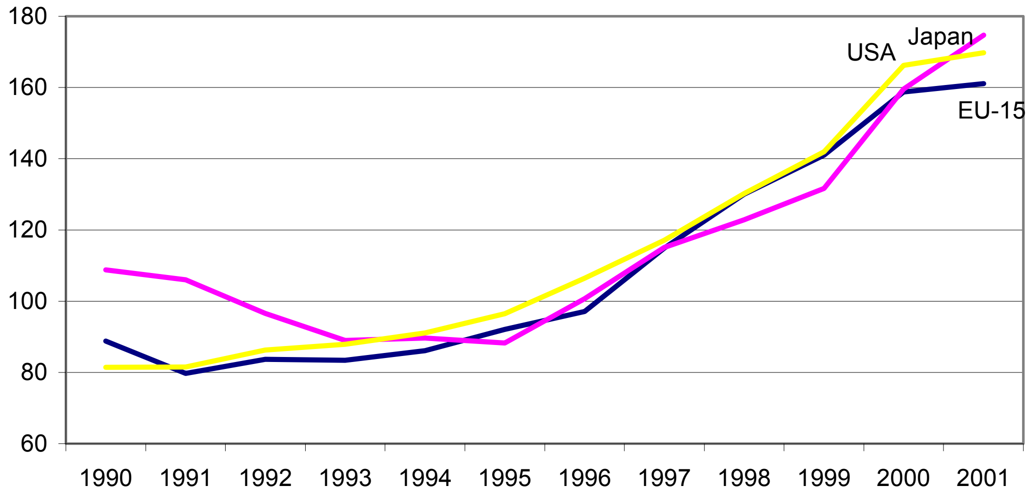
Comparing the EU with the US and Japan we find that the share of EU-15 in overall patent applications at the European Patent Office has gradually declined in the 1990s. By contrast the share of the US has increased considerably. If the trend would continue for another twenty years the natural home bias – read: home lead – of EU countries would no longer exist.

Fig. 2.: Percentage Shares of Patent Applications at the European Patent Office



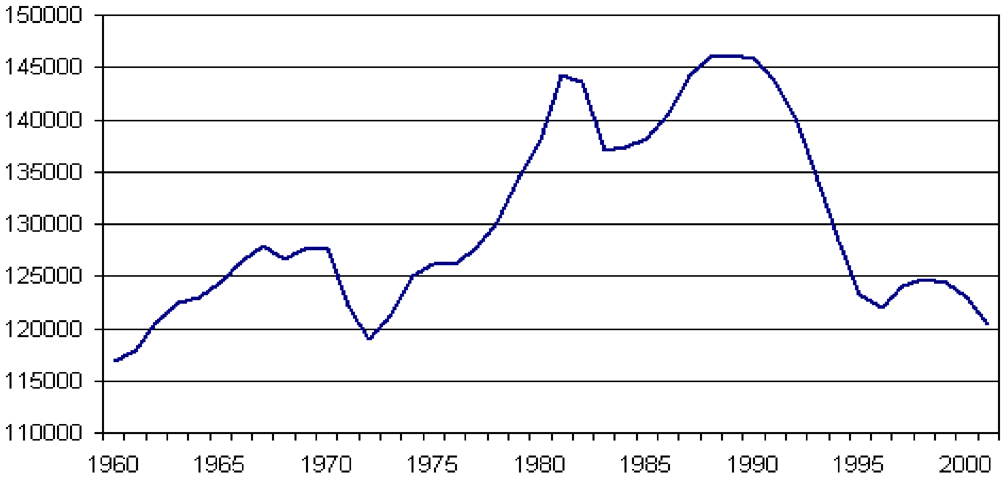
As regards the number of patent applications at the EPO per one million inhabitants the US and Japan were ahead of the EU-15 at the beginning of the 21st century. This also points to a certain weakness of EU innovation dynamics. From this figures it is fairly clear that the EU will be unable to reach the Lisbon target and become the world's leading economy in terms of competitiveness.

Fig. 3.: EU-15, Japan and USA: Number of Patent Applications Per One Million Inhabitants at EPO



A particular problem is Germany where the stock of national patents has been declining in the 1990s. While taking a look at patent applications relative to applications of other countries means to consider marginal patenting dynamics the focus on the stock of patent gives a much broader picture. If we assume that the stock of knowledge enters the production function and if we approximate that variable by the stock of patents it is obvious that a declining stock of patents indicates a dampening vintage effect in the field of technology; moreover, if Schumpeterian rents are proportionate to the stock of patents – we assume that products made on the basis of patented technology can fetch relatively high prices in world markets – a decline in the stock of patents should indeed go along with reduced income growth.

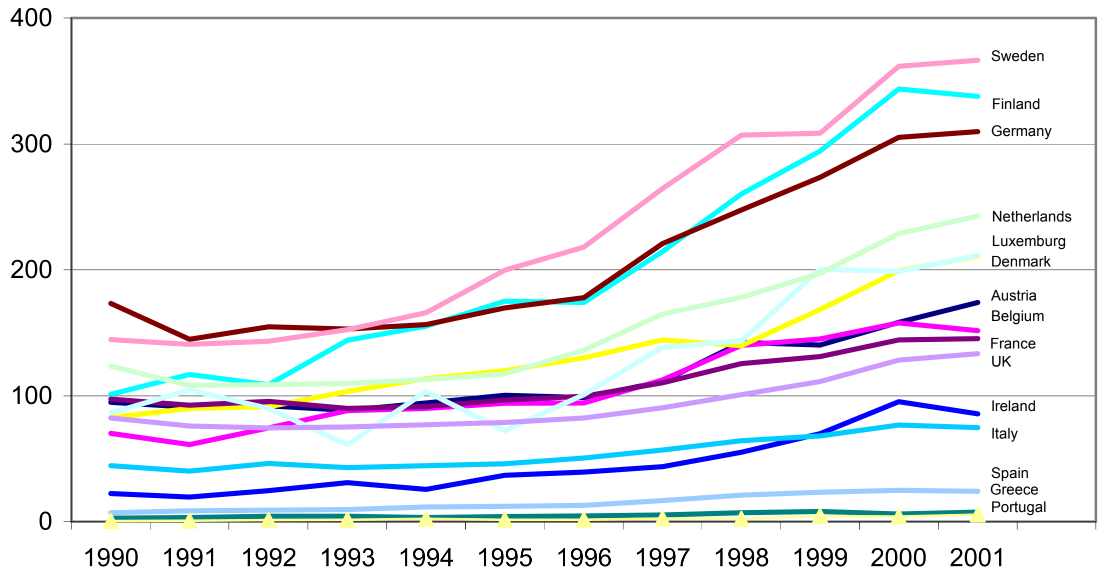
Fig. 4.: Stock of Patents at the German Patent and Trade Mark Office (1960 – 2001)



Source: Statistisches Bundesamt (various years), Statistisches Jahrbuch

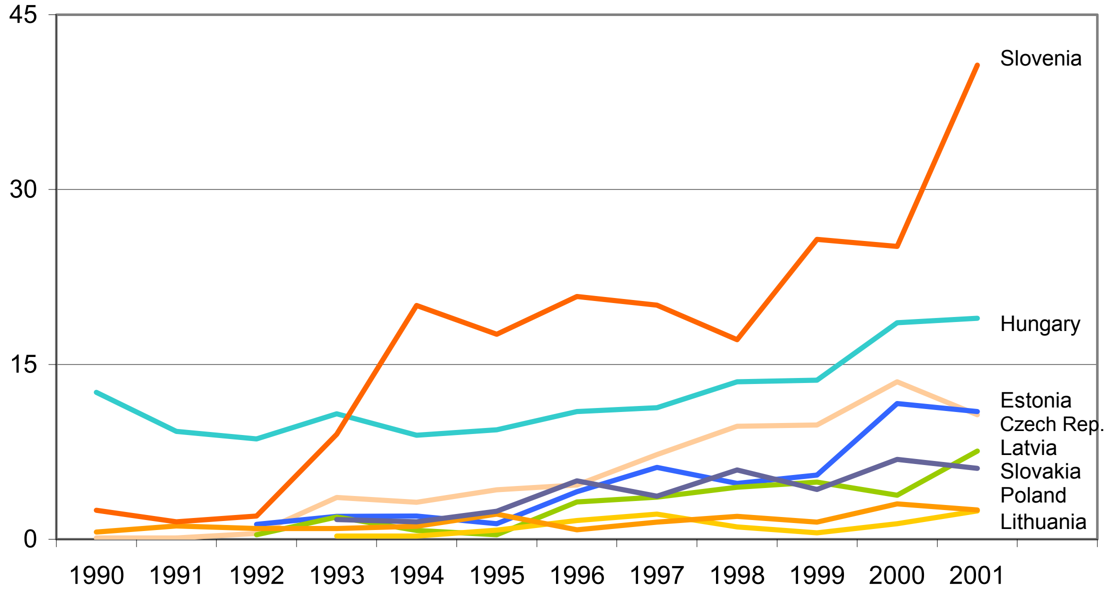
As regards per capita patent applications at the EPO several small EU countries were quite successful in terms of raising the respective figure, however, Germany, France and Italy have only a modest record.

Fig. 5.: EU 15: Number of Patent Applications Per One Million Inhabitants at the EPO



As regards EU accession countries patenting dynamics are relatively low, however, this is not surprising since they still have low per capita income and still modest ratios of R&D expenditures relative to GDP.

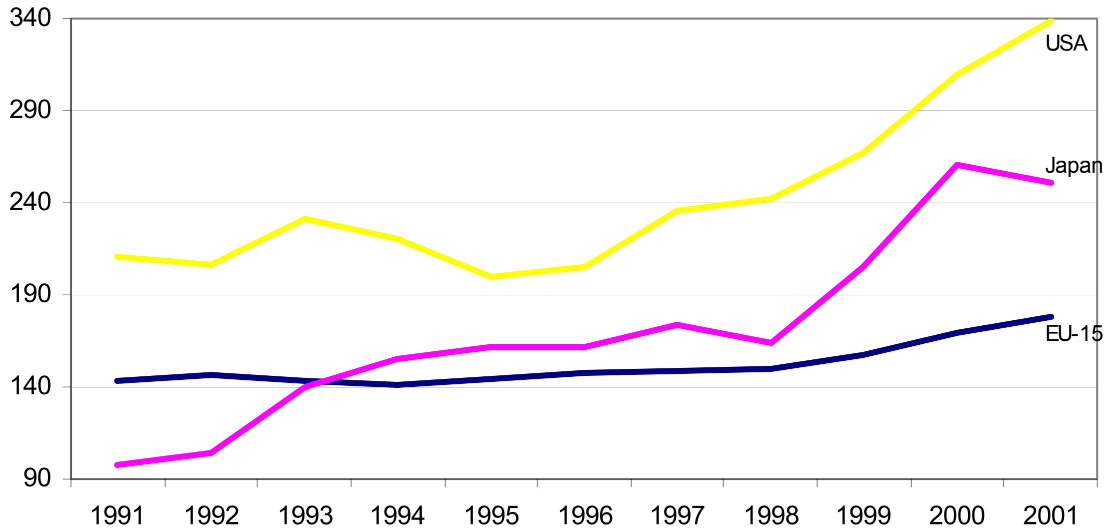
Fig. 6.: Central and Eastern European Accession Countries: Number of Patent Applications Per One Million Inhabitants at the EPO



There are, however, good prospects that continuing growth and foreign direct investment inflows in combination with rising public R&D expenditures – plus EU support – will raise patenting performance. For the accession countries there is still need to emphasize to some extent diffusion of new technologies and adoption of advanced technology. Generating higher innovation dynamics and technological upgrading is a necessary element of the medium term adjustment and growth process. There are indeed new empirical findings which show that Hungary, the Czech Republic and Poland (BORBÉLY, 2004) have embarked upon a process of structural change and economic and political catching-up. The analysis of trade between the EU-15 and selected accession coutries by means of a modified Revealed Comparative Advantage Index in the context of R&D expenditure shows, that Poland mainly specializes in the exportation of low and medium R&D intensive sectors, whereas the Czech Republic has clusters both in medium and high R&D intensive sectors, and Hungary specialises mostly in high technology products already. Although R&D expenditure ratios are still much lower in eastern European countries than in the current EU member states, the sectoral distribution of R&D expenditures is, however, similar.

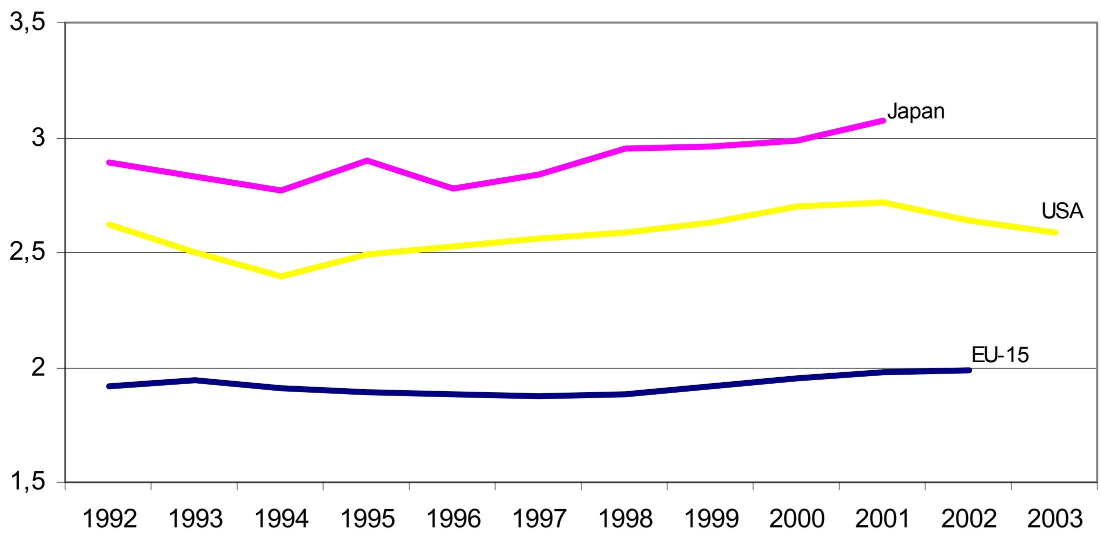
As regards R&D expdenditure per capita Japan and the US have shown a considerable growth in the 1990s while EU-15 has achieved only modest growth at the end of the decade.

Fig. 7.: R&D Expenditure Per Capita in EU-15, Japan and the USA (EUR, current prices)



As regards R&D expenditure in percent of GDP in the EU-15, Japan and the USA, it is obvious that Japan and the US have a clear lead compared to the EU, and the gap has not really narrowed in the 1990s.

Fig. 8.: R&D Expenditure in Percent of GDP in EU-15, Japan and the USA



3.3. Acceleration of Innovation Dynamics

The OECD countries have witnessed considerable differentiation in economic growth in the 1980s and 1990s on the one hand, on the other hand the rate of innovation – as measured by patent applications – has increased in the US and Europe in the 1990s (COUNCIL OF ECONOMIC ADVISERS, 2000; WELFENS/AUDRETSCH/ADDISON/

GRIES/GRUPP, 1999). The US has achieved a considerable lead in economic growth and technological progress vis-à-vis the EU in the 1990s which was characterized by an unusual increase in labor productivity in the second half of the economic cycle in the US (COUNCIL OF ECONOMIC ADVISERS, 2001). US labor productivity growth in the period 1973-1995 was 1.4% p.a., but in 1995-2000 it reached 3.1%. It is unclear what the reasons for the robust US productivity growth is. The Council of Economic Advisers has argued that falling computer prices and rising computer expenditures of wholesale trade, banking and the ICT sector itself play a crucial role for US growth in the 1990s. Moreover, there was a strong rise of multifactor productivity growth in the 1990s, and to a considerable extent this is related to information and communication technology (ICT); in the US both the production of ICT and the use of ICT – this is associated with ICT investment – have contributed to a strong growth of labor productivity in the 1990s. The picture for EU countries is heterogeneous: There are countries in which labor productivity growth in the services sector is more affected by ICT dynamics than in manufacturing industry (OECD, 2003).

The growth of the information and communication technology sector (ICT) in the 1990s has considerably contributed to growth in the US, especially in the second half of the 1990s. According to estimates by the US Department of Commerce (see the study DIGITAL ECONOMY) the ICT sector represented 8.3% of US output in 2000, but the sector contributed almost 1/3 of real GDP growth in the period 1995-99. Even more impressive is the contribution of ICT to investment in the US; it is noteworthy that computer prices have fallen strongly in the 1990s. In 1999 business spending for ICT equipment and software represented more than ¾ of the 12 percent real growth in total equipment and software spending. The contribution of the ICT sector in percentage points increased from 0.8% in 1994 when overall US growth was 4.2% to 1.6% in 1999 when the overall growth rate was close to 5%. In Europe only Finland and Sweden as well as Ireland, have an ICT sector which directly contributes significantly to economic growth. In 1989 Swedish Ericsson stood for about ½ percent of total Swedish GDP, but in 1999 the company stood for 2.6% of GDP and contributed 0.5 percentage points to economic growth. In Finland Nokia stood for 4% of GDP – and 1/5 of Finnish exports - and contributed a full percentage point to growth in 1999 (EUROPEAN COMMISSION, 2000).

The ICT sector (as defined by EITO, 2000) consists of IT-spending which reached 2.7% of GDP in the EU in 1999, but 4.5% in the US. Telecommunications accounted for 2.8% of 3.1% of GDP in the EU in 1999, for 2.8% in the US. Assuming that prices in the EU for telecommunication equipment and services are slightly higher than the US one may argue that the transatlantic differential in ICT spending is almost zero in telecommunications, but that the EU is far behind in the IT sector.

The use of telecommunications has contributed considerably to economic growth in the 1970s and 1980s in Germany, and the expansion of the internet could lead to a similar effect if it contributes to accelerating diffusion of information and knowledge, respectively (WELFENS/JUNGMITTAG, 1998, 2000; 2001; WELFENS, 2001). Network effects play a role both in the use of telecommunications and PCs (the internet).

As regards the US GORDON (1999) has argued that US growth acceleration in the second half of the 1990s – ignoring the cyclical effects – can fully be explained by the growth of output and productivity growth, respectively, in the computer producing sector and in the output of other durables. GORDON argues that there were no spillover effects in productivity to other sectors. GORDON argues that falling computer prices signal a falling marginal product of computer equipment. Subsequently, we will raise some doubts about this view. We also will look into the problem of modelling certain spillovers in a straightforward way. Indeed, we will address several aspects of the new economy and emphasize the potential role of spillover effects and network effects. One may also consider the GORDON (2000) argument about the limited role of computer expenditures in the US as flawed: He argues that the expenditure on computers as a share of nonfram private business has stagnated at 1.3% in the late 1990s, however, he completely overlooks that the US is the leading country in terms of software expenditures which accounted for 2.7% of GDP in 1995 – for comparison France 0.9% (OECD, 1998). Analyzing the role of computers – and semiconductors - without taking into account software expenditures obviously is inconsistent.

The 2003 European Innovation Scoreboard (EUROPEAN COMMISSION, 2003; SEC (2003) 1255) – the fourth Scoreboard realized, namely as part of the Lisbon strategy – has shown that the EU lags the US for ten out of eleven indicators available in both the EU and the US. Only in the field of science and engineering graduates did the EU beat the US. Fields with a gap were:

- high-technology patents at the US Patent and Technology Office (USPTO)
- USPTO patents
- Early stage venture capital in percent of GDP
- high-tech patents at the European Patent Office (EPO)
- Population with tertiary education
- High-tech manufacturing value-added
- Business R&D expenditures in percent of GDP
- Expenditures on information and communication technology (ICT) in percent of GDP
- Public R&D expenditures in percent of GDP
- EPO patents

On the basis of an Overall Summary Innovation Index which combines a look at the average change in SII trend indicators with the level of the indicator – in the range 0-1 – for the respective country Finland and Sweden are clear leaders while Germany, Netherlands and France are losing momentum; Italy is falling behind. The fact that except for the UK all large EU countries are facing problems raises serious worries. An important field in which, however, the EU is indeed catching up with the US concerns ICT as is noted in the 2003 European Innovation Scoreboard (EUROPEAN COMMISSION, 2003; SEC (2003) 1255, p. 10): "The only encouraging example of a long lasting catching-up process is in ICT expenditures (gap cut by 50% since 1996). Reaping the full benefits of this positive trend would require acceleration of organisational innovation following investment in ICT hardware." The 2003 summary innovation index (SII-2 which covers the 12 most widely available indicators from the Community Innovation Survey) shows that Greece, Portugal and Spain are catching up while the Netherlands, France and Germany are losing momentum. Another interesting finding is that there is a rising role of R&D expenditures in the services sector: For the overall EU the share of services in business R&D was 13% in 1999 which was 5 percentage points above the 8% in 1992. In Japan R&D in services represented 2% in 2000, up from 0.2% in 1992. In the US the share of business R&D has increased from 24% in 1992 to 34% in 2000. EU-25 countries which were found to rank high in terms of innovativeness also ranked high in terms of diffusion. As regards the response time of markets to innovative products the Scandinavian countries had relatively short response periods while Germany, Italy, Spain, France, the UK, Greece and Portugal had long response periods (TELIIS/STREMERSCH/YIN, 2003, in Marketing Science 22, 188-208; data for US and Japan not available).

3.4. Specialization in Innovation and ICT Network Perspectives

Analyzing the ICT sector means to look into technological dynamics, output-GDP shares and expenditure-GDP shares. Let us start with the simple observation that ICT is a highly dynamic sector of the economy. Judging by figures from the European Patent Agency the telecommunication sector has become that sector which has the highest growth rate of all patent groups; the growth rate in the period 1989-97 was 13.6% p.a., the growth rate of advanced electronics was 6.4% which made it No. 7 in the field of the ten fastest growing technology fields. This means that ICT is rather technology intensive and has some potential for technology spillovers (in the sense of the New Growth Theory à la Romer or else). The US plus Canada, the UK, Sweden and the Netherlands are positively specialized in telecommunications; they should strongly benefit from the global telecommunications boom which, however, will face some saturation problems in the long term when almost everybody has a mobile phone. In advanced electronics we find the US plus Canada and the Netherlands again, but also and strongly Japan.

Tab. 1.: Specialization (Relative Patent Share in interval -100, +100) in 1995-99 in Technology-intensive Fields with High Growth Rates in Patents*

	Growth	USA	Japan	Germany	France	UK	Switzerland	Canada	Sweden	Italy	Netherlands
Telecommunication	13,6	10	-3	-34	-7	17	-75	50	70	-67	18
Turbines	10,6	-8	-74	-40	87	8	83	-84	-7	-96	-52
Railway Systems	8,5	-74	-41	67	9	-67	58	-22	-19	0	-26
Paper-Making Equipment	7,6	-4	-88	28	-71	-43	-54	30	85	-41	-62
Automobiles	6,7	-47	-14	57	35	-31	-84	-71	-12	10	-56
Medi. Sector, Instruments	6,6	46	-80	-38	-36	-7	38	-64	32	-20	-29
Advanced Electronics	6,4	-18	46	1	-21	-18	-52	42	-52	-44	48
Power Distribution	6,4	-20	8	16	34	-23	-27	-53	13	-7	-36
Agrochemicals	6,1	35	-59	0	-3	5	22	52	-53	-13	-69
Medi. Sector, Electronics	5,8	42	-31	-47	-64	-9	-48	-19	10	-65	35

* Average Annual Growth of Patent Applications at the European Patent Agency in 1989-1997

Source: FhG-ISI, Karlsruhe, preliminary

According to these figures the US, Canada and the Netherlands stand to gain particularly from the ICT boom worldwide. Japan is likely to benefit mainly on the electronics side. In the New Economy, there is, however, one caveat with respect to patent figures; many internet-based services cannot be patented – copyrights and trade marks play an important role here.

Network Effects

As is well known the use of computers and modern telecommunication equipment often is characterized by network effects. For the initial users the network becomes more useful with additional users linked to it. Therefore users might actively promote the use of their network, but more importantly, networks – say AOL, MSN or YAHOO (giving some incentive to existing users) – have an incentive to encourage users to convince friends and family to also use the network. Network effects also can play a role in industry, especially if there are strategic technology alliances in technology intensive industries. Indeed, the number of technology alliances is particularly strongly in the US in the 1990s (COUNCIL OF ECONOMIC ADVISORS, 2001, p. 117).

A logistical function can be used to model network effects in the new economy, that is we can use the standard innovation diffusion model. Assume that Z(0)=1, the adoption rate for the innovation Z is given by the differential equation:

(C.1) $dZ/dt = aZ(L-Z)$

L is the exogenous population, Z the number of persons using the innovation - say a mobile phone, a PC or the internet - and L-Z the number not using it. Whenever pioneer users meet nonusers there is an "infection" effect which is desribed by the positive parameter a. In an economy which also is a heavy producer of the innovative product the diffusion parameter a is likely to be higher than in a setting where the innovative product is only used.

The solution of the above equation is given (see BECKMANN/KÜNZI, 1984, p. 130) by a logistical equation for the stock variable Z(t):

(C.2) $Z(t) = L/[1 + (L-1)e^{-at}]$

Note here that in an open economy the parameter a might be influenced by both the export-GDP ratio (x) and the import-GDP ratio (j) to the extent that the "infection" rate in the tradables sector is more intensive than in the nontradables sector; a simple suitable function could be $a= a_o(1+x+j)$. If the presence of foreign direct investment (FDI) at home and abroad reinforces international diffusion of knowledge an FDI stock proxy K"/Y and K"*/Y* for the stock of FDI at home and abroad relative to GDP might also affect the diffusion rate. Moreover, one could study an export function with standard products (1...n) and innovation products (m...z) where the innovation products are ranked according to novelty – with novel products assumed to fetch higher prices than standard products; innovation products are increasingly adopted by firms in the export sector. After some critical time T innovation products become standard products with no premium in the world market, that is prices are equal to marginal costs. The terms of trade thus will depend on the percentage of innovation products in the overall basket of export goods. We will not look in these special problems here. Rather we will continue with the above equation C.2. Denoting Z/L as z we have

(C.2′) $z(t) = 1/[1 + (L-1)e^{-at}]$

Assume that there is a dual use good (dual here refers to its double nature as consumption and investment good) – here mobile telecommunication devices that are first bought as consumption gooods – whose diffusion is described by (C.1) and (C.2), respectively; we use the following modified production function in which positive spillover effects from mobile telecommunication devices Z are entering:

(C.3) $Y = K^{ß}L^{1-ß} Z^{\sigma}$

The basic assumption here is that the use of computers in households has positive spillover effects in industry; there are knowledge spillover effects into output of firms whose aggregate value-added is Y. A special case which is easy to handle is where σ=1:

(C.4) $Y = K^{ß}L^{1-ß} L/[1 + (L-1)e^{-at}]$

In per capita terms we have (with y=Y/L and k=K/L):

(C.4′) $y = k^{ß} Lz(t)$

Interestingly, the size of the country plays a positive role for per capita income here. From this perspective there could be an advantage for large countries – with large markets (US or EU or other regional integration areas) – in the era of the New Economy. In such a model setup the size of the country matters. Comparing the NAFTA and Europe there is no reason to believe that Europe cannot benefit from size effects as much as North America plus Mexico.

An important aspect concerns the impact of the ICT boom on the wage-real interest rate-ratio. If ICT is partly Solow-neutral capital augmenting technological progress the ratio of wages to interest rates will increase which will stimulate US firms to relocate ICT production abroad. Say to Mexico, Ireland, Hungary or Malaysia. This means that ICT production in low income countries will grow so that the growth-enhancing effects of strong productivity growth in ICT finally arrives outside the pioneer country (US, partly Japan). If the host countries for foreign direct investment in ICT should reflect as small a group of host countries as for FDI in general in the 1980s and 1990s only two dozen countries worldwide will benefit from ICT product cycle trade.

In a Schumpeterian economy there will be a series of innovations coming to the market. If such innovations are not evenly distributed over time they can cause a spurt in growth when a cluster of innovations is entering the diffusion stage, later the growth rate will slow down. If this stimulates entrepreneurs to come up with new innovations – again being realized in a cluster-type fashing at some point t – there will be another economic upswing. Instead of using a single differential equation for one innovation, one will have to use a system of logistical equations for all products i (i=1...n). The new economy is generating logistical diffusion patterns both in the household sector – namely in the case of mobile telecommunication equipment and PCs plus internet use – and in industry (computers, internet use).

The GORDON view of computers and ICT is doubtful for several reasons. But further research is needed. From the human capital growth model it follows: Europe will fall behind the US in terms of per worker income if EU countries are not reducing unemployment rates and reducing tax rates and raising efforts on human capital formation. The most difficult problem in Europe is to finance higher education in private universities. European governments will find it very difficult to generate higher tax revenues in the era of globalization and the internet; unfortunately the idea of private universities (and vouchers) is unpopular in Europe. The competition of private universities would not only mean a higher stock of educational capital but also would stimulate the efficiency of teaching and research efforts in public universities. An economically meaningful investment-output ratio in the knowledge society should be defined as the weighted sum of the traditional investment-output ratio, the R&D-GDP ratio, the software expenditure-GDP ratio and the education expenditure-GDP ratio. In the latter three fields the US has a clear lead over Euroland and Germany, respectively.

4. Recommendations for Future EU Innovation Policy

The existing experience with EU framework programmes has shown that they are an important stimulus for internationalisation of research in the Community. At the same time it is obvious that the lessons from the mid-term of the 6^{th} framework raise some doubt in term of efficiency.

One major challenge in terms of research efficiency in the 6^{th} framework programme is that Integrated Projects have been introduced which consists of 15-25 partners and thus are very complex to administer for the coordinator in the research projects. The efficiency of such projects is thus rather limited. The benefit of integrated projects for the Commission is that it facilitates work for the EU authorities – in the sense that a rather limited number of projects has to be evaluated – but this is offset by efficiency losses in research itself as a high number of partners implies enormous coordination efforts (unless partners work together over many years). Therefore very large integrated projects – unless there specific reasons to aim at involvement of many countries and partners, respectively - stand for a doubtful approach which should be replaced by a new strategy with emphasis on:

- Specific Large Integrated Groups (SLIG) with a large number of partners should be continued; there are clear arguments in favour of a broad network. The Commission – and its advisors – should identify a limited number of areas deemed as suitable for Specific Large Integrated Projects. Areas earmarked as suitable for SLIP should not be exclusive so that other types of projects – in particular compact projects – should be allowed to compete.
- Many compact projects with a carefully selected small number of players could be quite successful. Small Integrated Projects (SIP) with not more than five partners; this requires that the Commission and the European Parliament, respectively, put up more resources for project evaluation. A relatively large share of resources should go to those projects. If projects reach high marks in evaluation the research group should be allowed to increase the number of partners provided that it has indicated such plans in a mid-term report. This would then result in two-stage Integrated Projects.
- Networks of Excellence should continue, but start on a rather limited number of actors (not more than 10). Research groups applying should indicate a two-stage plan for Network Extension in the Final Report; and networks with high marks in evaluation should then be allowed to apply for a Large Network of Excellence. However, the budget allocation for an enlarged network of excellence should be required to reflect growth in the number of partners underproportionately as the very idea of network effects suggests that efficient networks will be able to exploit economies of scale.

- For both networks of excellence and for integrated projects there should be standardized contracts available for research groups which bring together partners from industry and outside industry. The available experience from NoEs and IPs indicates that legal problems raised by industry partners in prospective international R&D groups impair the realization of both NoEs and IPs.

The proposed organizational improvements will bring enhanced R&D efficiency. However, this is not the most crucial issue when it comes to the topic how the EU could catch up with the USA. There is no doubt that the EU has fallen behind the USA in the 1990s in terms of innovativeness as measured by patent applications and share in high technology trade. A relatively weak performance has been measured in Germany whose poor economic performance after German unification raises many unpleasant questions.

From an EU perspective it is crucial that the transatlantic digital technology gap should be closed relatively quickly. At the same time the EU might want to maintain its lead in mobile telecommunications which seems possible in the medium term provided that UMTS services are quickly rolled out and that the US is not catching up very fast in 2G mobile telecommunication density.

Taking a look at the main budget items of the European Community – with No. 1 agriculture (share about 45%) and No. 2 structural funds (share about 1/3) – we do not find adequate priorities. Agricultural subsidies should be reduced to less than 20% of the EU budget while structural funds should be reformed in a way that would support more strongly retraining, education and support for research and development.

If both the production of ICT and the use of ICT are important for economic growth there could be two ways for high growth. Trying to become a country that has successfully specialized in ICT production or encouraging firms and households to quickly use the new technologies. As regards the use of new ICT and promotion of the diffusion process governments could have a role in countries which are not leaders in ICT production – namely to the extent that government can substitute for the diffusion impulses which come from ICT production in other countries. The Scandinavian countries, the Netherlands and Germany have embraced telecommunication liberalization energetically after 1998, the UK already before. This lets one expect that part of the EU could be a driving force in the European and global ICT revolution. However, while the EU partly looks strong in the field of telecommunications its role in the fields of computer and software looks relatively modest when compared to the US.

It would be useful to study the user patterns of internet users more closely – both with respect to the time budget and the structure of use. Moreover, the size of network effects and the significance of the role of spillover effects from household computer use should be estimated empirically. Part of the problems encountered here will refer to data problems as neither government nor industry has straightforward data which could tell where computers sold finally are used. But the data issue should be solved by survey analysis and other methods.

With EU eastern enlargement there will be pressure on EU-15 countries to move up the technology ladder. This should go along with increasing human capital formation which, however, raises the issue how the system of state-run universities will be able to cope with this challenge. The mixed US system – with private and public universities - has been impressive in its supply side elasticity in the 1990s when more than two million new jobs were created in the education system. Serious problems for EU countries could also emerge in education since the Maastricht criteria have increased the pressure for budget consolidation. This raises some critical questions for an adequate future policy mix in the

EU. There is a broader need for more comparative US-EU research – such research certainly could be helpful for identifying policy options to improve economic policy in all relevant fields of Schumpeterian dynamics.

The complex nature of EU coordination makes it necessary to focus supranational R&D policy strongly on market-oriented projects (related to tradable goods and services) on the one hand – here the link to market forces should help policymakers to largely avoid inefficient projects. One the other hand there are certain fields of fundamental research which is relevant for all EU countries so that the results of the respective R&D projects represent a regional international club good. Assuming that the EU scientific community will not have major problems in identifying priority fields of fundamental research it would be wise to assign responsibilities for the respective innovation policy at the supranational policy level. Avoiding unnecessary doubling of research expenditures and exploiting network economies within EU research groups should thus be possible. In fields in which there are no clear joint international research priorities it is up to the respective member country to allocate R&D expenditures on national innovation projects; the relatively transparent national policy approach should yield rather efficient outcomes of innovation policy.

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