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Innovations in the Digital Economy: Promotion of R&D and Growth in Open Economies

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Summary: This paper presents key figures on innovativeness and export dynamics in selected OECD countries and develops some new ideas on optimum R&D policies in open economies. We take a look at some selected indicators of technological and economic competitiveness in the field of RCAs and export unit values with a special focus on the US, France, Italy, Germany and the UK on the one hand and Hungary as an accession country on the other. Specialization patterns differ across countries; as do weighted export unit values. The US has been very successful in the 1990s in several key sectors which have improved both RCAs and export unit values. France has made progress in some high technology fields, Italy also stands for considerable successful structural adjustment. Germany's dynamics has been very strong in the automotive sector and in the field of precision instruments; however, Hungary and the UK also have a positive development in the automotive sector which could signal problems for Germany's exports in the lower segment of the market. As regards welfare effects of R&D support in particular, interesting cases concern technology-intensive intermediate tradables and network effects. We also emphasize the macroeconomic effects of government R&D subsidies for promoting product innovations and process innovations. It would be useful to have an EU (or OECD) tax revenue sharing system which would particularly compensate producers of intermediate innovative tradables. In a more general policy perspective, one may argue that the government should subsidize those technology-intensive fields in which the respective country has a comparative advantage or enjoys sustained increases in (weighted) export unit values. The new Schumpeter-Mundell-Fleming model presented clearly points to the benefits of an expansionary fiscal policy which would stimulate product innovations, with output and employment being higher. By contrast, there is an ambiguous result in the case of stimulating process innovations by way of expansionary supply-oriented (R&D promoting) fiscal policy. Knowledge transfer from universities to the business community would be stimulated by privatization of a considerable share of state-owned universities and the introduction of incentives for professors to create technology-intensive firms on or off campus. Knowledge and skills can be kept in the region only if the overall mix of policies creates positive growth prospects or if the country has specialized in immobile Schumpeter industries.

Zusammenfassung: Dieser Beitrag präsentierte Schlüsselzahlen zur Innovations- und Exportdynamik in ausgewählten OECD-Ländern, wobei die USA, Frankreich, Italien, Deutschland, Großbritannien und Ungarn im Vordergrund stehen. Dabei werden ausgewählte Zahlen zur technologischen und wirtschaftlichen Wettbewerbsfähigkeit betrachtet. Es gibt beträchtliche Unterschiede in den sektoralen Exportspezialisierungen und der Entwicklung bzw. den Schwerpunkten der gewichteten Exportdurchschnittserlöse. Die USA haben in einigen Feldern sowohl beim RCA wie bei den Exportdurchschnittserlösen große Erfolge in den 90er Jahren erzielt; Frankreich bei einigen Hochtechnologiefeldern. Auch Italien zeigt deutlichen Strukturwandel auf: mit Gewinner- und Verliererindustrien. Deutschland hat sich in den Feldern mit positivem RCA – Automobilbau und Präzisionsinstrumente – in den 90er Jahren verbessert; beim Automobilbau gilt dies aber auch für Ungarn und Großbritannien, was für Deutschland Probleme bei Niedrigpreis-Segmenten bedeuten könnte. Was Wohlfahrtseffekte von Subventionen für Forschung und Entwicklung (F&E) angeht, so sind interessante Aspekte bei technologieintensiven handelsfähigen Zwischenprodukten und im Kontext von Netzwerkeffekten zu bedenken. Betont werden hier auch die makroökonomischen Effekte von F&D-Subventionen, wobei Produkt- und Prozessinnovationen unterschieden werden. Es wäre gemäß den vorgestellten Überlegungen nützlich, ansatzweise ein EU-weites (auf OECD-weites) System der Steuereinnahmenaufteilung zu haben, um in diesem Rahmen die Nettolieferländer bei

technologieintensiven Zwischenprodukten zu kompensieren. Aus einer allgemeinen Politik-Perspektive kann man argumentieren, dass die innovationspolitische Förderung von solchen Technologiefeldern sinnvoll ist, in denen das Land einen komparativen Vorteil hat bzw. bei denen nachhaltige Anstiege des gewichteten Exportdurchschnittserlöses zu verzeichnen sind. Das neue Schumpeter-Mundell-Fleming-Modell, das hier präsentiert wird zeigt ökonomische Vorteile einer expansiven Fiskalpolitik auf, die Produktinnovationen verstärkt fördert. Hingegen ist eine expansive Fiskalpolitik zur Förderung von Prozessinnovationen in ihren Wirkungen Einkommens- und Beschäftigungswirkungen uneindeutig. Der Wissenstransfer zwischen Universitäten und der Wirtschaft kann durch Privatisierungen eines Teils der Universitäten und vernünftige Leistungsanreize für Hochschullehrer bzw. Forscher verstärkt werden. Um Wissen und Fähigkeiten in der jeweiligen Region zu halten, sind wachstumsförderliche technologieorientierte Politikstrategien wesentlich oder aber eine Spezialisierung auf immobile Schumpeter-Industrien.

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Innovations in the Digital Economy: Promotion of R&D and Growth in Open Economies

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1. Introduction

Starting in the 1980s, a new wave of economic globalization has brought about a relative increase of foreign direct investment and hence a rising role of multinational companies (MNCs). MNCs are crucial for the diffusion of new knowledge, and those firms are also key actors in research and development. With China and a new Russia – plus the smaller former socialist CMEA countries of Eastern Europe – opening up to the world economy, new players have entered global markets and competition has intensified. The end of the Cold War has intensified the global innovation race for civilian products as the share of military R&D expenditures in the US, France and the UK has fallen to close or less than 50%.

There is a long-term upward trend in the ratio of expenditures on research and development (R&D) to national income. While the ratio of R&D to GDP was close to 1% in OECD countries in the 1960s, it reached about 2% in the 1980s and is moving towards 3% at the beginning of the 21st century. Technological competition has increased since expenditures on research and development have grown relative to GDP. While process innovations have reduced production costs, product innovations stand for novel goods for which consumers (or investors) show a higher willingness to pay than for standard products. Product innovations also tend to raise profitability of firms and hence stimulate investment. While innovations in industry are often reflected in patents, innovations in services are more difficult to protect through intellectual property rights. A special case is software which enjoys copyright protection and more recently patent protection in the US. Technological competition also increased in the 1990s and the early 21st Century, because global diffusion of new knowledge accelerated due to the expansion of the internet.

With the expansion of the digital economy, there is an increasing role of innovative services whose significance is rather difficult to assess since patenting is relatively rare. Moreover, while a rise of export unit values (corrected for inflation) is, to some extent, a useful indicator for assessing the novelty of a product, a similar analytical category for services is not available. First, many tradable services are intra-company services for which transfer prices are applied which might reflect the tax considerations of multinational companies rather than the novelty of the service provided. Second, many services are nontradable, thereby bringing identification problems in the context of the Balassa-Samuelson effect, which suggests that the relative price of nontradables will increase parallel to the rise of per capita income. (There is also the more general problem that the effects of process innovations which reduce costs and product innovations – which raise the willingness to pay – often overlap in reality). This structural relative price effect makes it difficult to relate price increases in services to the degree of innovativeness in the provision of services. Thirdly, productivity measurement in services is more difficult than in industry, which makes the distinction between product innovations and process innovations cumbersome. Finally, many services are provided by government which has a particularly weak record in measuring productivity growth and in developing innovations. In a modern services society, it is hardly conceivable to fully exploit technological dynamics without carefully nurturing and stimulating innovativeness in the services sector, a point which has largely been overlooked in the Lisbon agenda of the EU aimed at making the union the most competitive economy in the world by 2010.

As regards technologically-leading countries, the US saw an acceleration in both economic growth and patenting in the 1990s. With respect to the EU, growth was slower than in the US in the 1990s, but the combination of the single market and EU enlargement in 2004 should allow higher growth in the EU-25. According to the Lisbon summit, the EU is to become the most competitive knowledge-based economy by 2010, a goal which includes the aim of raising employment rates considerably. The Lisbon goal cannot be achieved if EU member countries do not see improvements in the growth of output and employment. Germany, France, Italy and the UK play a key role here. The smaller open economies achieved a solid performance in the late 1990s with higher growth, higher employment and reduced budget deficits or even surpluses bring achieved. (The latter holds true even for Finland, which had a record high 18% unemployment rate in 1993 yet only 9% in 2004).

While the UK achieved full employment and sustained growth in the 1990s, the three core countries of the Euro zone still have to make progress. High unemployment rates in France, Italy and Germany are key problems with close to 30% unemployment in Southern Italy and Eastern Germany. A wide range of policy reforms in Germany in 2003/2004 (Hartz reforms) is likely to yield positive effects in terms of both lower unemployment and higher employment ratios within a medium-term adjustment period. However, restoring sustained growth is a different issue, as is overcoming the economic West-East divide in Germany.

The German government has declared that raising expenditures on R&D promotion relative to GDP is a medium term policy priority. It is unclear whether the German states, which account for roughly ½ of government R&D expenditures, will contribute significantly to this goal. Both national and regional governments face the constraints of the Stability and Growth Pact, with Germany having exceeded the 3% deficit ratio in 2002, 2003, and 2004 (the latter year judging by the deficit ratio of the first half of 2004). Hence, Germany – and other EU countries with similar problems – will face serious dilemmas in raising R&D expenditures.

EU enlargement and economic globalization mean a changing international division of labour. The new international division of labour at the beginning of the 21st century is characterized by economic catching-up processes in newly industrializing countries of Asia – including China – and in Eastern Europe and Russia. Asian NICs are richly endowed with labour and have achieved rising capital intensity due to domestic investment and foreign direct investment. Former socialist countries in Eastern Europe and Russia are richly endowed with unskilled labour and human capital. Western Europe's high wage countries must increasingly specialize in technology intensive and knowledge intensive products. Focusing on the ratio of R&D-expenditures to GDP, Sweden as the OECD leader reached 4% at the beginning of the 21st century. As regards the ratio of expenditures on higher education to GDP, Sweden is No. 2 behind the USA. As regards R&D expenditures, Germany achieved 2.4% of GDP in 2003, slightly higher than in the years before but much lower than the 2.9% of 1989. Germany's problems with the 3% deficit ceiling impair efforts to raise expenditures on R&D and education, and similar problems can be found in Italy and France. While the US spends about 2.5% of GDP and Sweden (and Finland) about 1.7% of GDP on higher education, Germany spends only 1% of its GDP in this field for which German states are almost exclusively responsible. The latter also contribute to roughly 50% of public R&D expenditures. Skilled labour is largely complementary to R&D (and R&D requires skilled labour inputs itself). As regards skilled labour, this category is not only represented by university graduates, rather skilled labour is also related to training activities in firms. With workers' tenure falling gradually in large firms in Europe, the incentive for firms to invest in training and retraining is falling. The New Growth Theory has emphasized the role of R&D, skills and differentiated products.

Economic globalization forces firms to relocate production more often on an international scale, and the risk to train workers for domestic and foreign competitors also fails to encourage firms to reinforce training activities. To the extent that globalization places stronger pressure on capital markets to come up with a high return on investment in the short term, this could also undermine firms' long-term activities to invest in human capital. This could be a particular problem for Germany and Austria (as well as Switzerland) whose firms have a long record of investment in training and retraining. As international competitiveness always reflects relative competitive advantages, it is also noteworthy that many countries in the EU have caught up with the Federal Republic of Germany in terms of infrastructure capital, R&D expenditures and education expenditures (relative to GDP). EU eastern enlargement has opened up new opportunities for the relocation of industry, and often supplier firms – they are expected to deliver on-time innovative high quality inputs ("complex subsystems") – follow the foreign investment of large companies, thereby accelerating the international transfer of know-how and knowledge. Moreover, the internet reinforces the international diffusion of knowledge so that first mover advantages could fade away more quickly.

These developments as well as the long record of high unemployment raise many questions in terms of raising innovativeness, accelerating structural change and launching adequate policy reforms for high wage countries. The careful exploitation of opportunities to raise productivity in the information and communication technology (ICT) could be a new and important policy element (BARFIELD/HEIDUK/WELFENS, 2002). Raising labour productivity has been an important element of high growth in the US and several EU countries in the 1990s. While there is no debate about the productivity-enhancing role of ICT production, it is less clear that the use of ICT – linked to ICT capital accumulation – strongly contributes to higher growth of output and productivity. (A strange case is productivity measurement in the US retail sector where a firm with 10 employees selling 10 standard PCs in 1999, but 10 more modern PCs in 2000– worth 5 times as much, according to hedonic price measurement, as a 1999 PC – shows up as a productivity growth of 500%!) Production of computers or telecommunication equipment seems to be crucial for growth.

Given the increasingly important role of innovation dynamics for international markets, the promotion of research and development becomes a crucial part of economic policy. The traditional argument in favour of R&D promotion is the existence of positive external effects which imply that marginal social benefit exceeds marginal private benefits of R&D expenditures. However, some new developments in innovation dynamics have to be taken into account when raising the issue as to which role government should assume in the promotion of innovation and skills.

2. Innovations and New Economic Structures in the Digital Economy

2.1. Selected Innovation Traits in OECD Countries

Product innovations allow for the increase in product prices in world markets and hence the earning of high incomes (wages and profit). Process innovations are equivalent to cost reductions and allow firms to fetch higher market shares and high incomes, in particular if price elasticity is larger than unity or if increased market share also allows for the exploitation of dynamic scale economies (e.g., learning by doing effects). Innovation dynamics can be assessed in different ways:

- Innovation expenditures, usually scaled by sales ("R&D intensity"); this in an R&D input indicator

- Patents per capita (R&D output indicator)
- Product innovation rate (new products to the market in % of sales, survey data, innovation output indicator)
- Diffusion rate (new-to-the-firm products, figures are from surveys)

Taking a closer look at selected EU countries as well as the US and Japan, one finds that Sweden, Germany and Finland were leading in R&D intensity in manufacturing (6.4, 4.7 and 3.9, respectively, in 2003; EU average 3.45; see Tab. 1). France and the Netherlands achieved 3.1, the UK 3.0. Germany's R&D intensity in the services sector was much weaker, namely 1.6 compared to the EU average of 1.8. Sweden was a clear leader in this field. France and the UK recorded 1.6 and 1.4, respectively. It is interesting to observe that in the field of product innovations in manufacturing, Germany was below the EU average despite its leading position in R&D intensity. Finland, Sweden and France were leading countries in the field of product innovations. This suggests that the German innovation system might have considerable efficiency problems. A similar picture is found in production innovation in the services market. As regards diffusion indicators, Germany is a leading EU country. Moreover, Sweden and Germany recorded a high ratio of New-to-firm to New-to-market in the manufacturing industry, which points to relatively fast diffusion (this could reflect strong competition).

Table 1: European Innovation Scoreboard, 2003

European Innovation Scoreboard 2003 - Member States, US and Japan

	EU 15	DE	FR	NL	AT	FI	SE	UK
Innov exp manuf	3.45	4.71	3.08	3.07	2.83	3.91	6.42	2.96
Innov exp serv	1.83	1.64	1.57	0.79	0.92	0.96	19.11	1.39
New-to-mark prods manuf	10.5	7.1	9.5	-	8.4	27.2	3.5	9.5
New-to-mark prods serv	7.4	3.7	5.5	-	4.3	12.2	9.3	-
New-to-firm prods manuf	28.6	40.3	17.5	23.8	23.1	31.1	32.1	-
New-to-firm prods serv	18.8	16.4	17.1	13.9	12.8	18.8	23.7	-
New-to-firm/New-to-mark prods manuf	2.7	5.7	1.8	-	2.8	1.1	9.2	-
New-to-firm/New-to mark prods serv	2.5	4.4	3.1	-	3.0	1.5	2.5	-

Source: European Commission (2003), Staff Working Papers, European Innovation Scoreboard 2003, page 27, Brussels and own calculations.

Against such apparent innovation weakness, one might consider it surprising that Germany has such a high current account surplus, e.g. 5% of GDP in 2002. However, 90 billion net exports recorded in 2002 would quickly melt away if full employment could be restored; investment would increase by about 10% or by about Euro 20 bill., consumption also by about 5% or 60 bill., which would leave net exports down at Euro 10 bill. The assumption here is that consumption is a positive function of disposable income and a negative function of the expected unemployment rate u^E. Investment is assumed to depend negatively on the real interest rate and the expected unemployment rate. To put it differently, a high net export position of a country with a high unemployment rate cannot simply be considered an indicator of high international competitiveness. Rather, it largely reflects weak domestic demand. The reduction of net exports in the case of rising employment and hence a falling expected and actual unemployment rate will hold even if one takes into account the expansionary impact of higher employment on the supply side. This perspective is, of course, not to deny that in a situation of high net exports (and also in the case of net imports: see the US in the 1990s), certain sectors are positively successfully-specialized in production and export of technology intensive or innovative products.

International competitiveness in specific sectors can be assessed on the basis of revealed comparative advantage indicators (RCA: sectoral export-import balance relative to overall export-import balance in the EU15 single market with an indicator above 1 indicating a positive sectoral competitive advantage) or with respect to export unit values. A sectoral increase in the weighted export unit value indicates an improved competitiveness in the EU single market as higher prices can be fetched in a very competitive market (there might, however, be cases where changes in market power or government intervention also affect the export unit value).

Denoting the aggregate price level as P and aggregate output as Y while sectoral outputs in sectors i and j are denoted as Y_i and Y_j, respectively – the respective prices are P_i and P_j – we can write:

(1) $YP = Y_i P_i + Y_j P_j$

(2) $Y = Y_i[P_i / P] + Y_j[P_j / P]$

Denoting the ratio of Y_i / Y as α and relative prices P_i / P and P_j / P as φ' and φ'', respectively, we thus can write the aggregate growth rate as

(3) $g_y = \alpha\varphi'[g_{yi} + g_{\varphi'}] + (1-\alpha)\varphi''[g_{yj} + g_{\varphi''}]$

Denoting the revealed comparative advantage in sector i as R_i we assume that

(4) $\alpha = \alpha(\varphi', \varphi'', R_i)\partial\alpha / \partial\varphi' > 0; \partial\alpha / \partial\varphi'' < 0; \partial\alpha / \partial R_i > 0$

As $Y_i / Y = \alpha(\varphi', \varphi'', R_i)$ we can write – with E denoting elasticities:

(5) $g_{yi} = E_{\alpha\varphi'} g_{\varphi'} + E_{\alpha\varphi''} g_{\varphi''} + E_{\alpha Ri} g_{Ri} + g_y$

and hence (taking into account that $Y_i / Y = 1 - \alpha$ and that therefore – assuming that a is small and hence $\ln 1 - \alpha \approx \alpha$ – the growth rate $g_{yj} = -da / dt + g_y$:

$$
\begin{aligned}
(6)\quad & g_y[1 - \alpha\varphi' - (1-\alpha)\varphi''] = \alpha\varphi'[E_{\alpha\varphi'} g_{\varphi'} + E_{\alpha\varphi''} g_{\varphi''} + E_{\alpha Ri} g_{Ri} + g\varphi'] \\
& + (1-\alpha)\varphi''[\alpha_{\varphi'} d\varphi' / dt + \alpha_{\varphi''} g_{\varphi''} + \alpha_{Ri} dRi / dt + g_{\varphi''}]
\end{aligned}
$$

From this it follows that economic growth in the simple two-sector model can be explained by the two relative prices and the RCAs (a positive RCA in sector i corresponds to a negative RCA in sector j and vice versa). According to the Heckscher-Ohlin theory the RCA in turn should depend on relative factor endowments.

Higher RCAs and higher export unit values in certain sectors are likely to contribute quite strongly to output growth in the long run. Scale intensive sectors and science intensive sectors are obviously two potentially relevant sectors. In a high wage economy, emphasis on science-based products can strengthen competitiveness through product innovations which will temporarily lead to rising export unit values and hence higher profitability. This is a Schumpeterian perspective which leads away from perfect competition. Scale intensive products also imply that the perfect competition model does not hold. In some cases, scale intensive products exhibit both static and dynamic scale economies so that high production volumes could be combined with first mover advantages.

Interestingly, the US has achieved a higher export unit value in all fields where it has enjoyed a positive comparative advantage This suggests a positive feedback mechanism in the sense that a higher export unit value goes along with increased profitability which in turn reinforces investment and hence should contribute to an improving RCA.

Table 2: USA – RCA, EUV, EUV weighted with the sectoral export shares of manufacturing and of GDP

NACE rev.1 (2-digdigi	RCA			EUV 2001	EUV 1993	dEUV	EUV 2001	EUV 1993	dEUV
	2000/01	EUV 2001	EUV 1993	Weighted (export share)	Weighted (export share)	Weighted (export share)	Weighted (GDP share)	Weighted (GDP share)	Weighted (GDP share)
15	0,24	0,40	0,26	0,01	0,01	0,00	0,16	0,11	0,06
16	0,07	2,04	1,64	0,00	0,00	0,00	0,02	0,01	0,00
17	0,28	6,85	5,28	0,04	0,06	-0,02	0,95	0,67	0,28
18	0,11	28,16	17,75	0,06	0,11	-0,05	1,25	1,23	0,02
19	0,16	9,17	11,17	0,02	0,04	-0,03	0,39	0,48	-0,09
20	0,79	1,37	0,82	0,01	0,01	0,00	0,21	0,14	0,08
21	0,50	0,84	0,50	0,01	0,01	0,00	0,29	0,12	0,16
22	**1,10**	**14,21**	**9,48**	**0,14**	**0,11**	**0,03**	**3,07**	**1,20**	**1,87**
23	0,29	0,11	0,09	0,00	0,00	0,00	0,02	0,01	0,00
24	**0,91**	**3,95**	**2,25**	**0,52**	**0,32**	**0,20**	**11,56**	**3,50**	**8,06**
25	0,57	8,00	6,13	0,14	0,13	0,00	3,09	1,49	1,61
26	0,49	3,91	2,66	0,03	0,02	0,01	0,65	0,24	0,41
27	0,53	7,35	4,33	0,21	0,14	0,07	4,75	1,54	3,21
28	0,56	12,57	8,64	0,18	0,13	0,05	3,90	1,43	2,48
29	**1,24**	**20,61**	**14,22**	**2,16**	**1,57**	**0,59**	**48,12**	**17,43**	**30,70**
30	**1,40**	**144,84**	**117,88**	**22,11**	**20,29**	**1,82**	**492,25**	**225,17**	**267,08**
31	**1,31**	**35,90**	**25,52**	**1,60**	**1,01**	**0,58**	**35,52**	**11,22**	**24,29**
32	**1,93**	**252,79**	**125,42**	**27,94**	**8,35**	**19,59**	**622,02**	**92,67**	**529,35**
33	**3,64**	**150,75**	**84,41**	**13,41**	**7,53**	**5,88**	**298,58**	**83,58**	**214,99**
34	0,20	9,73	6,96	0,32	0,22	0,10	7,06	2,43	4,63
35	**4,73**	**299,91**	**76,10**	**53,81**	**10,36**	**43,45**	**1197,95**	**114,99**	**1082,96**
36	0,97	22,27	12,45	0,44	0,23	0,22	9,89	2,50	7,39

Note: Fields of positive RCAs are bold typed; strong improvement in GDP-weighted export unit value is underlined; fields of declining export unit value are in Italics.

The US has achieved a strong increase in the GDP weighted export unit value in NACE 30, 32, 33 and 35, respectively: manufacture of office machinery and computers; manufacture of radio, television and communication equipment and apparatus; manufacture of medical, precision and optical instruments, watches and clocks; manufacture of other transport equipment (e.g. airplanes). US companies apparently are well positioned to fetch higher prices in those sectors which stand for a relatively large share of the economy. In the fields of NACE 32 and 35 the improvements in export unit values also stand for a large share of US exports. The rise of the export unit value was quite impressive in NACE 32 and NACE 35 in which the respective value doubled and nearly quadrupled, respectively. In NACE 35 the US export value is three times as high as in the case of France, five times as high as in the case of Germany, ten times as high as in the case of Italy and about fifty times as high as in the case of Hungary.

As regards export unit values and the change of export unit values over time, one should also take a look at weighted export unit values so that the relative economic significance of certain sectors can be understood. As regards Germany, it is well-known that the country has a positive RCA – read RCA above unity – in both the automotive industry and in other transport equipment (NACE 34 and 35). Taking a closer look at German industry, one can see that specialization in terms of RCA changed slightly in the decade after 1993. Germany has one important loser industry (see by contrast Italy), namely NACE 19 which stands not only for a negative RCA but also for declining export unit values: tanning and dressing of leather, manufacture of luggage, handbags, saddlery, harness and footwear; NACE 17 and 18 – they are classified as labor intensive sectors – also show weak international competitiveness (RCA<1); sectors 28 and 36 which also are labor-intensive show at least an improvement of export unit values. There is a high RCA in the manufacturing of fabricated metal products (NACE 28, not including machinery and equipment). It is also noteworthy that the export unit value has increased over time for this product group. In the field of office machinery and computers (NACE 30) – a sector which (together with NACE 32: telecommunications equipment) is considered highly relevant for productivity growth –, Germany has a negative RCA. Worse yet, the export unit value in this sector has declined. NACE 32 has improved over time. The overall picture with respect to the long term development of export unit values in German industrial export reveals that export unit values – average revenue per quantity unit (e.g. kilogram of steel etc.) – showed few changes over the period from 1993 to 2001. Which sectors are most important for economic dynamics: In a narrow sense those sectors which show a positive RCA and a high weighted export unit export value; this at least is the concept presented here. As regards the economic significance of export unit values it is indeed useful to take a closer look at weighted unit values where sectoral shares in overall manufacturing exports are taken as weights: considering only weighted indicators reaching at least 0.75 (hence export unit value must be high or the share of the respective sector in overall export of manufacturing) – see the bold figures in the respective tables - we see that 29, 30, 32, 33, 34 and 35 are crucial sectors for Germany; 32, 33, 34 (33 and 34 stand for the automotive sector; 32 is medical, precision and optical instruments, watches and clocks) are important sectors in each of the three countries considered, 35 and 29 only in Germany and the UK, 31 only in Hungary.

Note that the change in the weighted export unit value of 32, 33 and 34 was positive in Germany, the UK and Hungary over the period 1992-2001; and this should translate into relatively rising wages for skilled workers as we may assume that these sectors are using skilled labor intensively. Interestingly, 18 (wearing apparel) which stands for labor intensive production is important in both the UK and in Hungary. Moreover, 18 stands indeed for a positive RCA both in the UK and in Hungary (figures underlined in the subsequent tables). As regards Germany 29, 33, 34 and 35 stand for an economically significant positive RCA, in the UK we have 29, 34 and 35 (note that 29 and 34 both stood for a positive RCA in the UK and Germany in 2000/01); as regards Hungary we find 18, 30, 31, 32, 34 as positive RCA: 34 is an overlap with the UK and Germany. The fact that Hungary could improve the weighted export unit value strongly in 34, the automotive sector, points to a strong catching-up process in the Hungarian automotive sector. To the extent that this finding is representative for accession countries in eastern Europe Germany's automotive firms acting in the lower quality segments of the market might face profitability problems in their German plants. The new international division of labor in Europe suggests that mass production of standard cars will be largely relocated to eastern Europe's low wage countries. Hence the respective regions will face serious labor reallocation challenges in the early 21st century.

In sector 18 there is an overlap of Hungary with the UK; NACE 30, 31 and 32 indicate successful Hungarian specialization. However, note that 31 and 32 - differentiated goods (this also includes 29) – stand for relative footloose industries: the manufacturing of office machinery and computers (30) and of electrical machinery and apparatus n.e.c. (31) could internationally be relocated relatively quickly.

As regards Germany it is important to not that the country – in contrast to the UK (whose labor productivity has reached about 80% of the German level in the 1980s and 1990s) has no positive RCA in labor intensive industries - and this is surprising in a country which has more than four million unemployed; most of which are unskilled workers. One may consider this finding as an indicator for insufficient wage differentiation in Germany.

Obviously in all three countries medium technology fields are important for export dynamics and RCAs, respectively. One should point out that RCAs typically follow relative sectoral patent positions. A rising share in global patents in the respective sector translates with a time lag of 3-4 years into an improved sectoral RCA. Hence expenditures on research & development and innovation policies are important.

Compared to the apparently stable German industrial specialization pattern, Hungary has launched a rather impressive catching-up process since reinforcing the RCAs in some technology intensive sectors and was also able to fetch higher export unit values – a proxy for its ability to extract high prices in competitive EU market – in EU-15 markets. Hungary has many fields which have shown a rise of the export unit value.

The British industry, whose relative size has declined over decades, still has certain fields in which it shows considerable strength. Interestingly, RCA and export unit values in labour intensive production increased in the period between 1993 and 2001, which obviously is consistent with the improved employment record of the UK. In all five labor intensive sectors the UK has a positive RCA (RCA>1) and has achieved an improvement in export unit values. At the same time, the UK has also improved its position in science intensive products. Particularly important is NACE 30 (office equipment and computers), where the export unit value has improved over time while the RCA remained fairly stable below unity. The UK has shown a strong weighted improvement of the export unit value in NACE 32, the manufacturing of radio, television and communication equipment. With respect to the UK, considerable employment growth in the overall economy must, however, be explained largely by the expansion of the services sector. To some extent, it seems surprising that the UK has a positive RCA (exceeding unity) in only a few sectors. Moreover, where RCA is above unity, it is only weakly so. By contrast, Germany's industry shows some clear fields of comparative advantage as does Hungary, an interesting case of new economic dynamics in an EU accession country. It is quite noteworthy that Hungary achieved higher export unit values in several sectors. The table shows that weighted improvements of export unit values were strong in 30, 32 and 34, essentially electronic products which represent scale-intensive goods, science-based goods and differentiated goods.

Figure 1: Germany – RCA and Export Unit Values

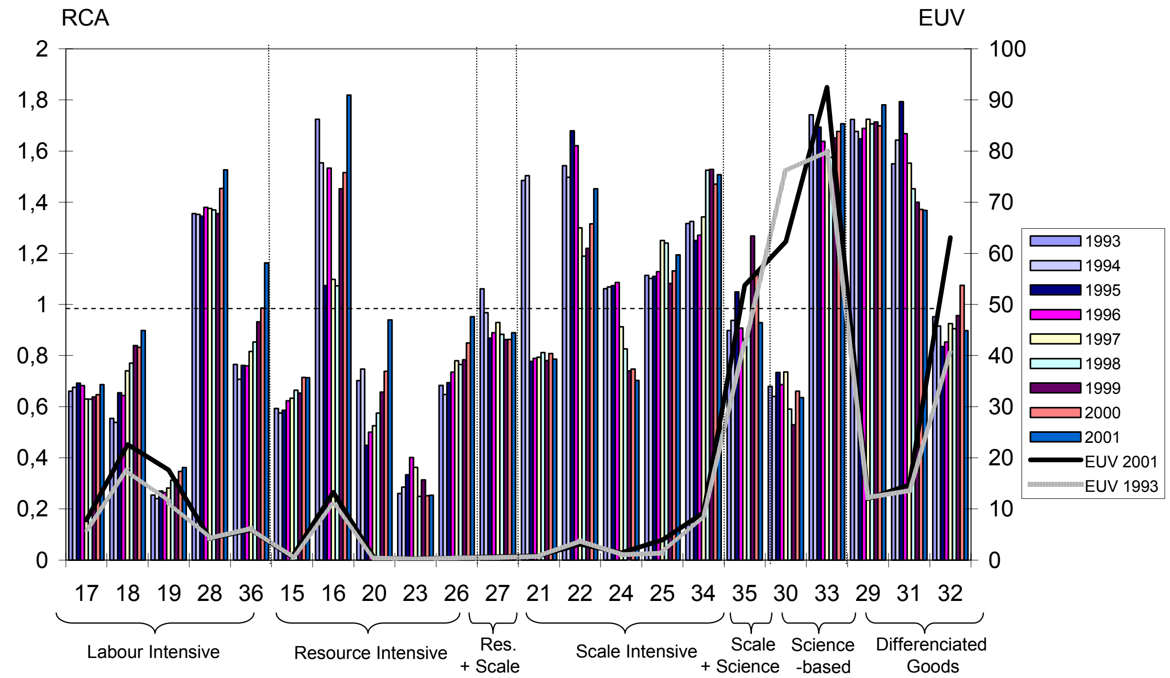


Table 3: Germany – RCA, EUV, EUV weighted with the sectoral export shares of manufacturing

NACE rev.1 (2-digit)	RCA 2000/01	EUV 2001	EUV 1993	EUV 2001 weighted (export share)	EUV 1993 weighted (export share)	dEUV weighted (export share)	EUV 2001 weighted (GDP share)	EUV 1993 weighted (GDP share)	dEUV weighted (GDP share)
15	0.71	0.62	0.52	0.03	0.03	0.01	8,55	2,93	5,62
16	**1,67**	**13.25**	**10,82**	**0.07**	**0.05**	**0.01**	**8,37**	**4,00**	**4,37**
17	0.67	7,82	6.12	0.13	0.10	0.03	20,67	11,22	9,44
18	0.86	22.60	17.51	0.33	0.26	0.07	25,94	13,86	12,08
19	*0.35*	*17.65*	*11,39*	*0.08*	*0.05*	*0.03*	*0,89*	*4,96*	*-4,07*
20	0.84	0.38	0.40	0.00	0.00	0.00	0,43	0,15	0,28
21	0.80	0.85	0.73	0.02	0.02	0.00	3,58	1,56	2,02
22	**1,38**	**3.11**	**3,83**	**0.03**	**0.04**	**-0.01**	**5,21**	**2,81**	**2,40**
23	0.25	0.26	0.18	0.00	0.00	0.00	0,64	0,10	0,55
24	0.72	1,43	1.01	0.16	0.11	0.05	28,49	11,78	16,71
25	**1,16**	**3,92**	**1,38**	**0.13**	**0.05**	**0.09**	**21,49**	**9,50**	**12,00**
26	0.90	0.43	0.44	0.01	0.01	0.00	1,17	0,60	0,57
27	0.88	0.66	0.51	0.04	0.03	0.01	6,50	2,10	4,40
28	**1,49**	**4,22**	**4,18**	**0.14**	**0.14**	**0.00**	**21,27**	**9,46**	**11,81**
29	**1,74**	**12.02**	**12,20**	**1,50**	**1,52**	**-0.02**	**197,64**	**96,45**	**101,19**
30	0.65	62.26	76.05	4,29	5,24	-0.95	799,70	208,07	591,63
31	**1,37**	**14.70**	**13.64**	**0.69**	**0.64**	**0.05**	**101,16**	**35,49**	**65,68**
32	0.99	63.06	40.44	3,54	2,27	1,27	561,74	113,08	448,66
33	**1,69**	**92.49**	**80.01**	**3,16**	**2,73**	**0.43**	**217,73**	**114,93**	**102,80**
34	**1,49**	**9,27**	**8,80**	**1,94**	**1,84**	**0.10**	**307,56**	**107,29**	**200,27**
35	**1.03**	**53.74**	**42.32**	**2,53**	**2.00**	**0.54**	**341,70**	**163,22**	**178,48**
36	**1.07**	**5,92**	**6,28**	**0.12**	**0.12**	**-0.01**	**19,83**	**8,25**	**11,58**

Figure 2: Hungary – RCA and Export Unit Values

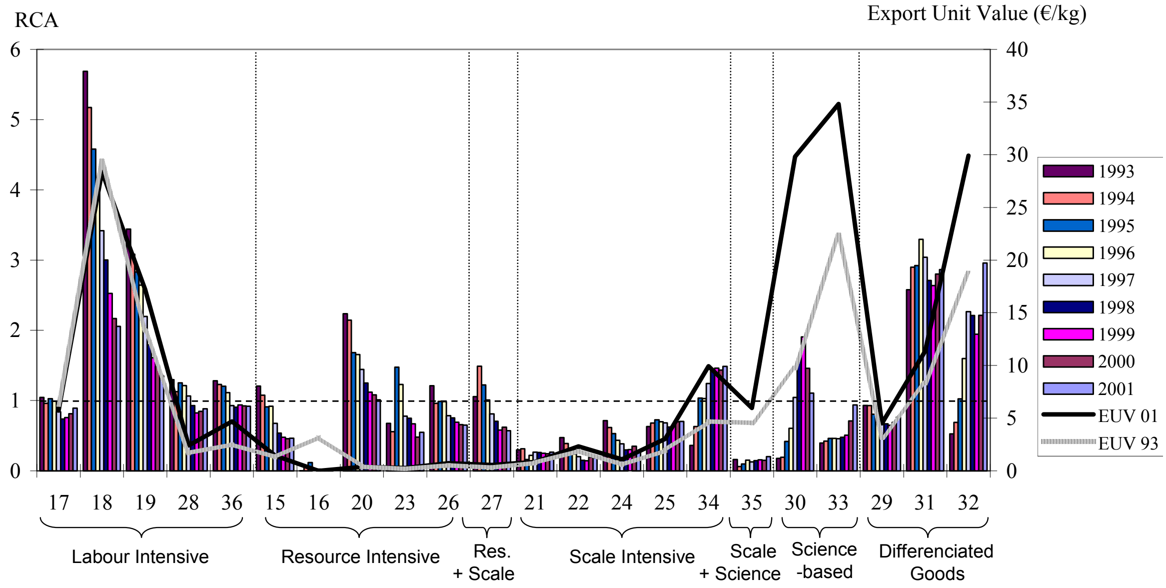


Table 4: Hungary – RCA, EUV, EUV weighted with the sectoral export shares of manufacturing or respective sectoral shares in GDP

NACE rev.1 (2-digit)	RCA 2000/01	EUV 2001	EUV 1993	EUV 2001 weighted (export share)	EUV 1993 weighted (export share)	dEUV weighted (export share)	EUV 2001 weighted (GDP share)	EUV 1993 weighted (GDP share)	dEUV weighted (GDP share)
15	0,46	1,45	1,27	0,05	0,04	0,01	19,29	16,37	2,92
16	0,00	0,00	3,19	0,00	0,00	0,00	0,00	0,00	0,00
17	0,85	5,72	6,29	0,11	0,12	-0,01	48,85	26,15	22,70
18	**2,11**	**28,39**	**29,41**	**1,05**	**1,09**	**-0,04**	**494,83**	**438,19**	**56,65**
19	**1,42**	**17,21**	**13,31**	**0,28**	**0,21**	**0,06**	**118,38**	**70,66**	**47,72**
20	1,05	0,37	0,38	0,00	0,00	0,00	1,62	0,63	0,99
21	0,25	0,84	0,75	0,01	0,01	0,00	2,72	0,50	2,22
22	0,19	2,32	1,89	0,00	0,00	0,00	1,69	0,83	0,87
23	0,51	0,27	0,18	0,00	0,00	0,00	1,59	0,29	1,30
24	0,31	1,09	0,56	0,04	0,02	0,02	22,93	5,09	17,85
25	0,70	3,04	1,93	0,07	0,04	0,02	27,75	4,43	23,32
26	0,65	0,73	0,53	0,01	0,01	0,00	2,89	1,46	1,44
27	0,60	0,56	0,29	0,02	0,01	0,01	8,56	1,76	6,80
28	0,87	2,40	1,69	0,05	0,04	0,02	21,86	6,41	15,45
29	0,73	4,51	3,16	0,29	0,20	0,09	113,75	26,54	87,21
30	**1,28**	**29,81**	**9,74**	**3,59**	**1,17**	**2,42**	**2503,98**	**9,06**	**2494,92**
31	**2,83**	**11,36**	**8,32**	**1,10**	**0,81**	**0,29**	**489,95**	**74,79**	**415,16**
32	**2,59**	**29,91**	**18,76**	**5,06**	**3,17**	**1,89**	**1624,24**	**35,17**	**1589,07**
33	0,82	34,83	22,37	0,80	0,51	0,29	198,11	20,40	177,71
34	**1,46**	**9,93**	**4,68**	**2,35**	**1,11**	**1,24**	**941,11**	**20,94**	**920,17**
35	0,18	5,96	4,54	0,05	0,03	0,01	6,85	2,63	4,23
36	0,92	4,69	2,50	0,09	0,05	0,04	37,21	8,30	28,91

Note: Fields of positive RCAs are bold typed; strong improvement in GDP-weighted export unit value is underlined; fields of declining export unit value are in Italics.

Figure 3: UK – RCA and Export Unit Value

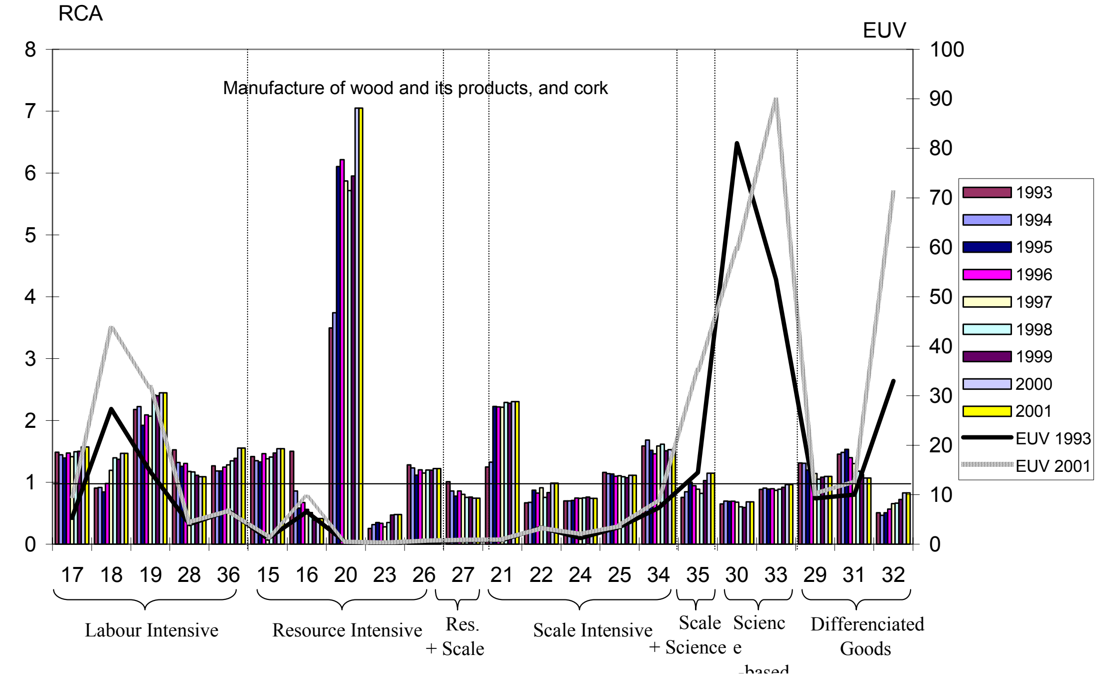


Table 5: United Kingdom – RCA, EUV, EUV weighted with the sectoral export shares of manufacturing and of GDP

NACE rev.1 (2-digit)	RCA 2000/01	EUV 2001	EUV 1993	EUV 2001 weighted (export share)	EUV 1993 weighted (export share)	dEUV weighted (export share)	EUV 2001 weighted (GDP share)	EUV 1993 weighted (GDP share)	dEUV weighted (GDP share)
15	**1,54**	**1,42**	**1.09**	**0.10**	**0.08**	**0.02**	**10,51**	**8,35**	**2,15**
16	0.41	9,48	6,53	0.01	0.01	0.00	5,47	0,62	4,85
17	**1,57**	**9,72**	**5,33**	**0.22**	**0.12**	**0.10**	**14,20**	**10,73**	**3,47**
18	**1,47**	**43.62**	**27.33**	**0.75**	**0.47**	**0.28**	**50,97**	**32,08**	**18,89**
19	**2,45**	**31.73**	**14.65**	**0.39**	**0.18**	**0.21**	**9,44**	**6,13**	**3,31**
20	**7.05**	**0.52**	**0.37**	**0.01**	**0.00**	**0.00**	**0,14**	**0,08**	**0,06**
21	**2,30**	**0.91**	**0.82**	**0.03**	**0.03**	**0.00**	**1,79**	**1,24**	**0,55**
22	0.99	3,31	3,33	0.03	0.03	0.00	9,62	6,64	2,98
23	0.48	0.28	0.13	0.00	0.00	0.00	1,27	0,58	0,69
24	0.74	2.02	1,25	0.22	0.14	0.08	33,81	17,26	16,55
25	**1.11**	**3,72**	**3,44**	**0.10**	**0.09**	**0.01**	**10,91**	**6,70**	**4,21**
26	**1,22**	**0.68**	**0.48**	**0.01**	**0.01**	**0.00**	**0,98**	**0,61**	**0,37**
27	0.74	0.88	0.75	0.03	0.03	0.01	4,67	2,41	2,26
28	**1.09**	**4,37**	**4.05**	**0.09**	**0.09**	**0.01**	**8,67**	**4,09**	**4,58**
29	**1.10**	**10.12**	**9,26**	**0.81**	**0.74**	**0.07**	**55,21**	**45,32**	**9,88**
30	0.68	59.74	81.05	9.10	12,35	-3.25	1.637,93	395,74	1.242,19
31	**1.07**	**12,73**	**9,98**	**0.43**	**0.33**	**0.09**	**52,73**	**21,90**	**30,82**
32	0.83	71.05	32.98	5,88	2,73	3,15	984,86	134,29	850,57
33	0.96	89.80	53.50	2.05	1,22	0.83	175,40	108,45	66,95
34	**1,53**	**9.10**	**7,36**	**1,51**	**1,22**	**0.29**	**98,09**	**47,35**	**50,74**
35	**1,15**	**35.19**	**14.48**	**1,16**	**0.48**	**0.68**	**169,52**	**63,42**	**106,09**
36	**1,56**	**6,82**	**6,72**	**0.15**	**0.15**	**0.00**	**14,48**	**8,24**	**6,23**

Table 6: France – RCA, EUV, EUV weighted with the sectoral export shares of manufacturing and of GDP

NACE rev.1 (2-digit)	RCA 2000/01	EUV 2001	EUV 1993	EUV 2001 weighted (export share)	EUV 1993 weighted (export share)	dEUV weighted (export share)	EUV 2001 weighted (GDP share)	EUV 1993 weighted (GDP share)	dEUV weighted (GDP share)
15	**1,19**	**0,99**	**1,07**	**0,09**	**0,16**	**-0,07**	**13,09**	**11,13**	**1,96**
16	0,27	7,03	4,75	0,01	0,00	0,01	1,28	0,32	0,97
17	0,92	4,20	5,84	0,09	0,20	-0,12	12,59	12,83	-0,24
18	*0,78*	*13,40*	*33,46*	*0,19*	*0,72*	*-0,54*	*27,65*	*47,64*	*-19,98*
19	0,45	11,10	13,97	0,06	0,12	-0,06	8,73	7,73	0,99
20	0,74	0,37	0,32	0,00	0,00	0,00	0,36	0,17	0,19
21	0,78	0,81	0,69	0,02	0,02	0,00	2,87	1,33	1,54
22	0,85	3,14	4,48	0,02	0,03	0,00	3,48	2,56	0,92
23	0,75	0,34	0,17	0,01	0,00	0,00	0,84	0,18	0,66
24	0,97	1,46	1,02	0,21	0,17	0,04	30,50	11,16	19,34
25	**1,07**	**3,45**	**3,72**	**0,11**	**0,14**	**-0,03**	**16,61**	**10,57**	**6,04**
26	0,95	0,56	0,49	0,01	0,01	0,00	1,19	0,76	0,43
27	**1,12**	**0,56**	**0,47**	**0,03**	**0,03**	**0,00**	**5,07**	**2,38**	**2,68**
28	0,81	2,78	2,79	0,06	0,07	-0,01	8,31	4,68	3,63
29	0,83	6,91	7,08	0,49	0,50	-0,01	72,10	38,88	33,23
30	0,68	36,65	82,90	2,70	4,11	-1,41	398,13	285,97	112,16
31	**1,06**	**6,92**	**8,29**	**0,25**	**0,29**	**-0,04**	**36,60**	**21,68**	**14,92**
32	**0,88**	**31,66**	**29,68**	**1,59**	**1,11**	**0,48**	**234,81**	**74,82**	**159,99**
33	*0,80*	*23,99*	*49,62*	*0,47*	*1,12*	*-0,65*	*69,53*	*70,81*	*-1,28*
34	**1,34**	**7,27**	**7,24**	**1,56**	**1,13**	**0,43**	**229,60**	**91,59**	**138,02**
35	**1,72**	**86,05**	**72,65**	**5,62**	**4,83**	**0,80**	**829,91**	**347,03**	**482,88**
36	0,74	5,18	2,52	0,08	0,10	-0,02	11,61	3,03	8,58

As regards France there is a clear loser, namely NACE 18: Manufacture of wearing apparel; dressing and dyeing of fur – here the export unit value has fallen. France has achieved considerable GDP-weighted increases in export unit values in EU markets in NACE 30, 32, 34 and 35 which is similar to the case of the US except that the US has shown a strong performance in 33 (manufacture of medical, precision and optical instruments, watches and clocks) and only a small increase in 34 (manufacture of motor vehicles, trailers and semi-trailers); France also recorded a small increase of the export unit value in NACE 29 (manufacture of machinery and equipment). Labor intensive sectors such as 17, 18, 19 seem to be problem for France since the RCA is below unity while export unit values hardly can be raised or even have fallen. NACE 28 and 36 which are labor intensive, too, have shown a modest increase in export unit values, however, there is no positive RCA (>1) in those sectors. France seems to have moved increasingly towards a high technology strategy, but it is unclear whether this can bring about sufficient growth to reduce unemployment rates strongly.

Table 7: Italy – RCA, EUV, EUV weighted with the sectoral export shares of manufacturing and of GDP

NACE rev.1 (2-digit)	RCA 2000/01	EUV 2001	EUV 1993	EUV 2001 Weighted (export share)	EUV 1993 Weighted (export share)	dEUV Weighted (export share)	EUV 2001 Weighted (GDP share)	EUV 1993 Weighted (GDP share)	dEUV Weighted (GDP share)
15	0,84	1,07	1,04	0,07	0,07	0,00	7,93	4,70	3,23
16	0,01	0,70	0,75	0,00	0,00	0,00	0,01	0,00	0,00
17	**2,79**	**9,53**	**10,83**	**0,59**	**0,96**	**-0,37**	**69,33**	**65,67**	**3,67**
18	***1,85***	***15,80***	***29,77***	***0,52***	***1,36***	***-0,83***	***61,52***	***92,67***	***-31,14***
19	**3,76**	**17,62**	**11,43**	**0,78**	**0,68**	**0,11**	**92,16**	**46,23**	**45,93**
20	0,62	1,30	1,49	0,01	0,01	0,00	0,84	0,53	0,31
21	0,68	1,12	0,99	0,02	0,02	0,01	2,72	1,24	1,48
22	0,89	2,69	2,88	0,02	0,02	0,00	2,51	1,48	1,02
23	0,49	0,28	0,15	0,00	0,00	0,00	0,36	0,11	0,25
24	0,65	1,79	1,30	0,17	0,10	0,07	19,81	7,00	12,82
25	1,46	2,95	2,90	0,13	0,13	0,00	15,50	8,73	6,77
26	**2,00**	**0,59**	**0,65**	**0,02**	**0,02**	**-0,01**	**2,10**	**1,70**	**0,39**
27	0,92	0,71	0,57	0,04	0,02	0,01	4,23	1,71	2,52
28	**1,72**	**2,58**	**2,57**	**0,11**	**0,10**	**0,01**	**13,07**	**6,92**	**6,14**
29	**1,99**	**6,19**	**6,35**	**1,04**	**0,96**	**0,08**	**122,32**	**65,92**	**56,40**
30	*0,29*	*56,58*	*89,47*	*1,81*	*4,88*	*-3,06*	*212,81*	*333,21*	*-120,39*
31	1,10	6,54	5,67	0,24	0,19	0,05	28,73	13,04	15,69
32	0,45	24,50	19,24	0,63	0,42	0,21	73,63	28,80	44,83
33	0,72	20,28	24,72	0,36	0,43	-0,08	41,91	29,62	12,29
34	0,77	6,32	5,81	0,78	0,48	0,30	91,19	32,51	58,68
35	0,95	24,99	21,79	0,90	0,82	0,09	105,96	55,71	50,25
36	**2,39**	**3,89**	**5,20**	**0,19**	**0,29**	**-0,10**	**22,38**	**19,76**	**2,62**

Italy has suffered in a traditional field of comparative advantage from a fall of the export unit value, namely in NACE 18 (manufacture of wearing apparel; dressing and dyeing of fur) which indicates stronger global price competition for an important sector of the Italian economy. There also was a strong fall of the export unit value in NACE 30 which is the crucial manufacturing of office machinery and computers, but in this group Italy also stands for a revealed comparative weakness as the RCA is much below unity. More encouraging looks 35 which is close to an RCA exceeding unity and where the export unit value has improved. Very encouraging is also NACE 19 – with a high RCA and improved export unit value - which is a traditional strength of the Italian economy: tanning and dressing of leather, manufacture of luggage, handbags, saddlery, harness and footwear. A successful adjustment also is found in NACE 28 and 29, respectively: Manufacture of fabricated metal products, except machinery and equipment (28) and manufacture of machinery and equipment n.e.c. (29). From this perspective Italy could benefit considerably from EU eastern enlargement both through rising exports of sophisticated consumption goods and of industrial goods. Moreover, Italy is similar to the UK with respect to the fact that all sectors classified as labor intensive show a positive – and indeed large - RCA. From this perspective the employment rate in Italy is strongly dependent on the international business cycle.

2.2. Innovation System and Innovation Record

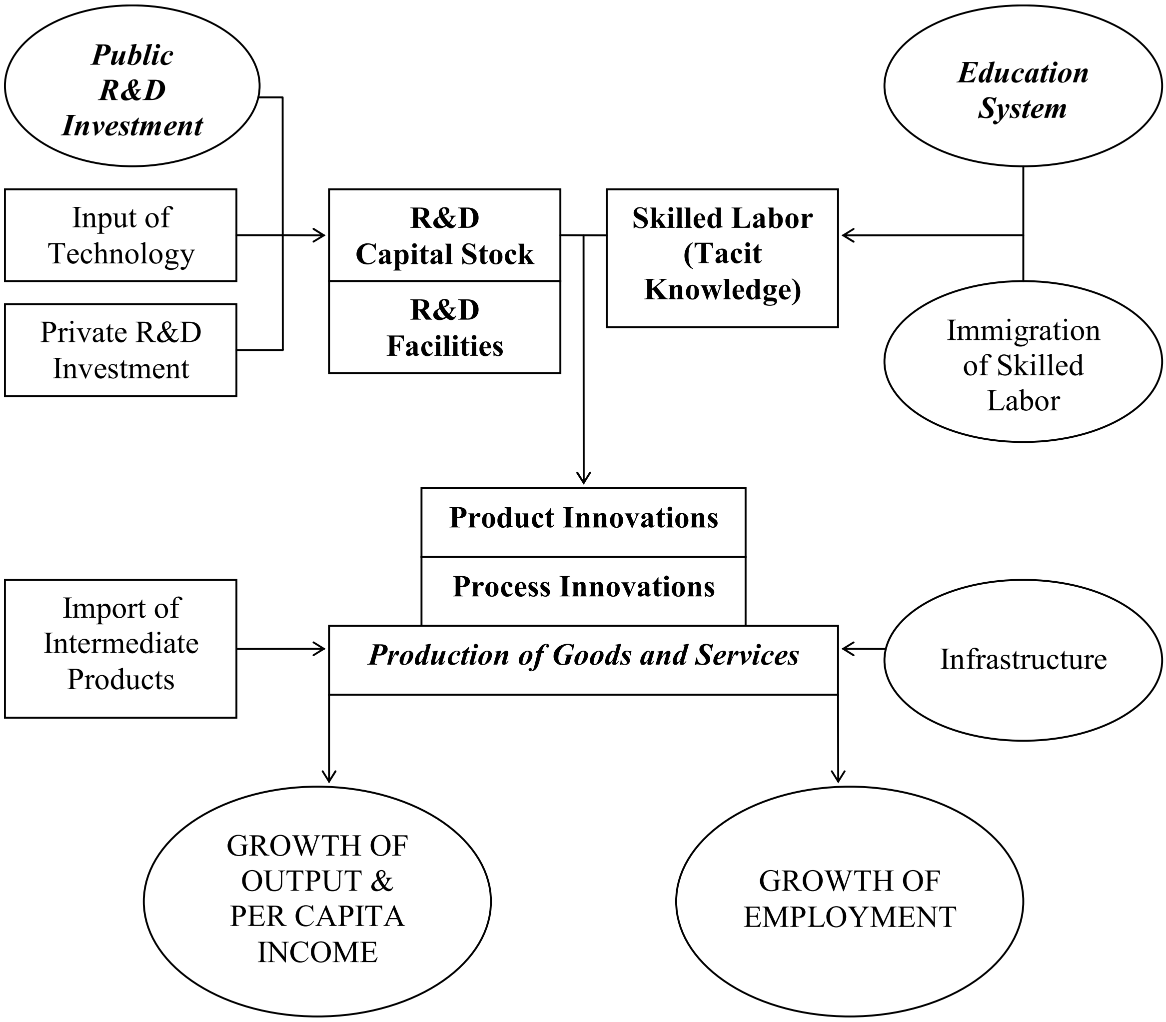
From a microeconomic perspective, the innovation process is clearly affected by incentives for the firm and the interdependency within the market. Key drivers of the innovation process are:

- adequate governance of the firm which is a crucial challenge particularly in large companies and in small companies growing fast;
- the expected rate of profit which is partly determined by first mover advantages, patenting performance and R&D subsidies;
- the intensity of competition and the growth of the overall market – intensive competition will typically stimulate innovations, and such innovations are easier to finance if the overall market is growing;
- technological dynamics – the 1990s witnessed an acceleration of patents of several countries in the US, above all of the US itself;
- locational advantages which include the availability of skilled labor and the associated tacit knowledge (codified knowledge is easily transferable, while tacit knowledge is immobile to the extent that skilled workers cannot be easily moved abroad).

As regards immobility of industries, one should point out that few technology intensive industries are really immobile, namely those where R&D activities and production activities cannot easily be separated geographically. This is typically the case in the air & space industry (high technology intensive which is a typical trait of the US industry and of part of the French industry) and in the production of specialized machinery and capital equipment (medium technology intensive which is a typical trait of German industry). High technology production is not generally immobile as the case of the chip industry clearly illustrates (e.g., one can develop the blueprint for a new generation of chips in California or Bavaria or Scotland, but after the first innovation stage, the production can be relocated to countries with low wage costs in Eastern Europe or Asia.)

Countries have different innovation systems as the interaction of government institutions, firms, universities and research labs has evolved within different countries in various ways. Innovation dynamics is not only a matter of specialization and human capital formation. In the case of integrated countries – e.g., in the case of the EU, ASEAN or NAFTA –, it is important to launch novel final products tailored to regional and global markets. What also matters at the level of the firm is the ability to adequately use the knowledge of specialized suppliers whose ability to develop novel subsystems is a crucial asset in the automotive industry of many countries. Moreover, using novel intermediate products imported from countries with successfully innovative firms is also an element of competitiveness in open economies. What matters more in the long run is the dynamics of the overall innovation system, which not only includes firms and their innovative suppliers but also specialized R&D firms, the innovative potential of researchers and labs at universities and the availability of modern infrastructure (roads, railways, airports, telecommunications). The incentives for innovation are partly intrinsic, partly in the form of expected rewards for which intellectual property rights and R&D promotion by government are important. Moreover, innovation is associated with a certain degree of risk, so that sustained high innovation dynamics require favourable access to equity capital including venture capital.

Figure 4: Actors and Institutions in the Innovation System



Continental EU countries have traditionally relied much on the banking system which, in turn, financed most investments and innovation projects on the basis of collateral. In a modern digital service economy, the availability of collateral, however, becomes a problem since knowledge and software play an increasing role for existing and new innovative firms. Compared to the continental banking system, Anglo-Saxon capital markets – with a strong tradition in venture capital financing – are easier sources of financing innovative projects in the services sector. This could undermine the dynamics of modern industry in continental EU countries to the extent that innovative services are crucial inputs for manufacturing products or a key element for optimum after-sale service. To the extent that US multinational services companies invest in Europe or Asia, innovative services might become available despite weaknesses of the respective domestic services sector. However, high profits earned in innovative service firms will then accrue in the US which, in turn, could thereby strengthen digital US growth. In high wage countries of the EU, it seems to be quite important that nurturing innovative services not be neglected.

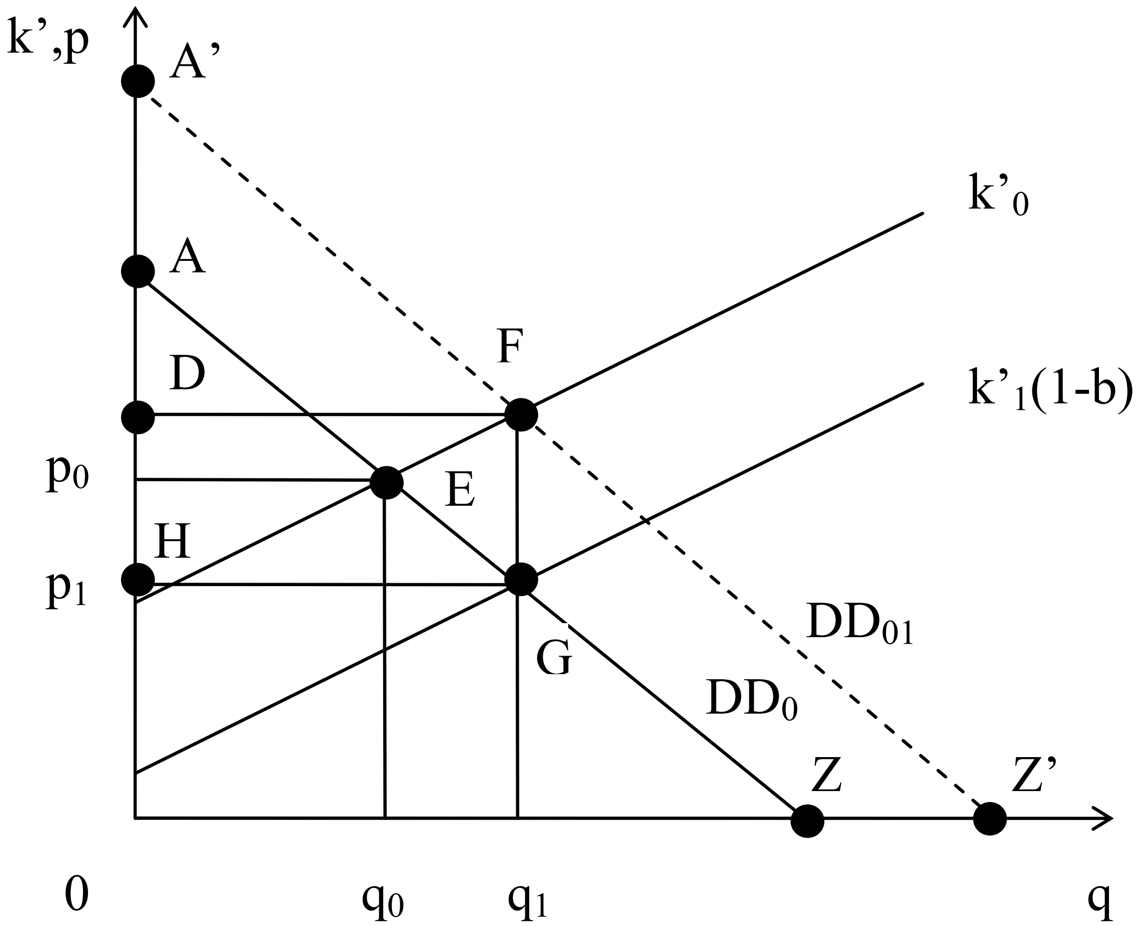
2.3. Theory of Innovation Policy

2.3.1. The Standard Case

Why should government support R&D? This is obvious when it has a particular individual interest in innovations as is the case in the field of defence. Besides this special sector, it is only in case of positive intersectoral or intrasectoral effects that R&D subsidies are adequate. Assume that the demand for an innovative product is given by the demand curve AZ (DD_0) – expressing private benefits – while social benefits are reflected by the demand schedule A'Z' (DD_{01}). As there are positive external effects of using the innovative product (or service), the optimum quantity will not be brought about by private markets themselves. The market would bring q_o while the optimum quantity is q_1; the latter would be produced if government reduces marginal costs by a fraction, b, so that there should be R&D subsidies. The price would fall to p_1 instead of p_0 in the simple market equilibrium. However, R&D subsidies would then amount to the area HGFD, which can only be financed through (income) taxes, in turn shifting the AZ curve downward. Taxation in turn will impose deadweight losses – that is, reduce economic welfare – unless the tax is on activities with a negative external effect. Since the latter case can be assumed to be relatively rare, the optimum R&D subsidy is slightly smaller than indicated by the subsidy rate, b. Moreover, subsidization of R&D makes sense only if the increase in net welfare is higher than the costs of subsidization. These costs could ultimately include the costs of other sectors calling for equal treatment: read subsidization (while not showing positive external effects). In addition, there is a risk that government combines R&D subsidies with interference in the business sector which can cause efficiency losses. As a practical issue, one also has to look into the issue of granting subsidy payments or offering tax credits for R&D intensive firms. Subsidy payments appeal to the lobbying and rent-seeking efforts, particularly of large firms. Tax credits are a superior instrument to the extent that R&D intensive small and medium-sized firms can also benefit from this relatively easily.

Government also plays a role in the field of intellectual property rights. In the digital economy, intellectual property rights have come under pressure because the violation of copyrights is rather easy (see e.g., the Napster trial).

Figure 5: Product Innovation with Positive External Effects and R&D Promotion

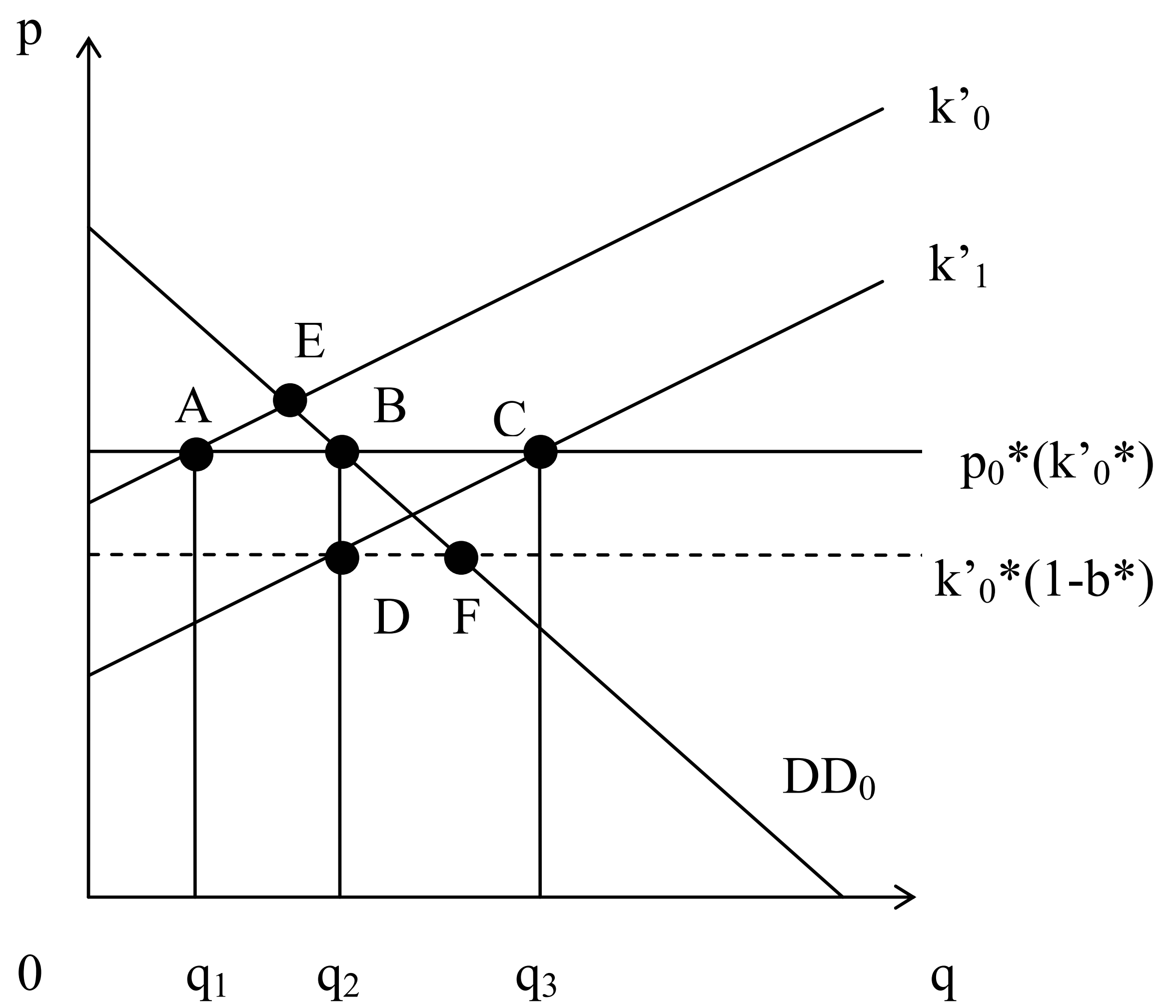


Making profits by selling digital contents is not easy. There are technical reasons for this problem, but there also is a lack of adequate legislation in some countries. Germany has introduced national legislation that is supposed to implement the EU e-commerce directive. As regards copyrights, Germany's new laws clearly weaken the copyrights of authors, thereby reducing the incentive to develop quality contents for traditional and digital publications.

In an open economy, it is important to understand that subsidies can influence trade (Fig. 6). If the world market price is $p^*_{0,}$ the initial situation without R&D subsidies implies net imports of AB. If country I (home country) subsidizes R&D so that the marginal costs schedule shifts downwards, we would have net exports equivalent to the distance BC. If country II ("the rest of the world") also introduced subsidies – pointing to the positive external effects of R&D –, the world supply curve would shift downwards so that country I would be a net importer again. The quantity imported would thereby be equivalent to the distance DF. The problem with R&D subsidies and trade is that such subsidies are adequate to the extent that the subsidy rate reflects positive external effects (at home and abroad). Since the size of external effects of innovation is very difficult to assess, subsidization in technology-intensive tradables sectors naturally presents a potential field of controversy.

Country I – assuming it to be a globally leading country in the respective sector – might argue that R&D subsidies in this sector abroad are adequate since positive external effects in other countries should be relatively small. Yet country I might argue that other countries aim at catching market shares by way of unfair subsidization. If the sector concerned has dynamic scale economies in the long run or is characterized by an international oligopoly, there are additional aspects to be considered. International rent-shifting opportunities will particularly accrue to first movers and large aggressive firms which, in turn, should enjoy particular opportunities if the home market is large and characterized by high per capita income. In a large home market, it is fairly easy to exploit static- and dynamic-scale economies. Countries such as the US, Japan, the EU – and in the future, China or India – offer special opportunities in this respect. Thus, it would not be surprising if trade conflicts emerge between these large economies.

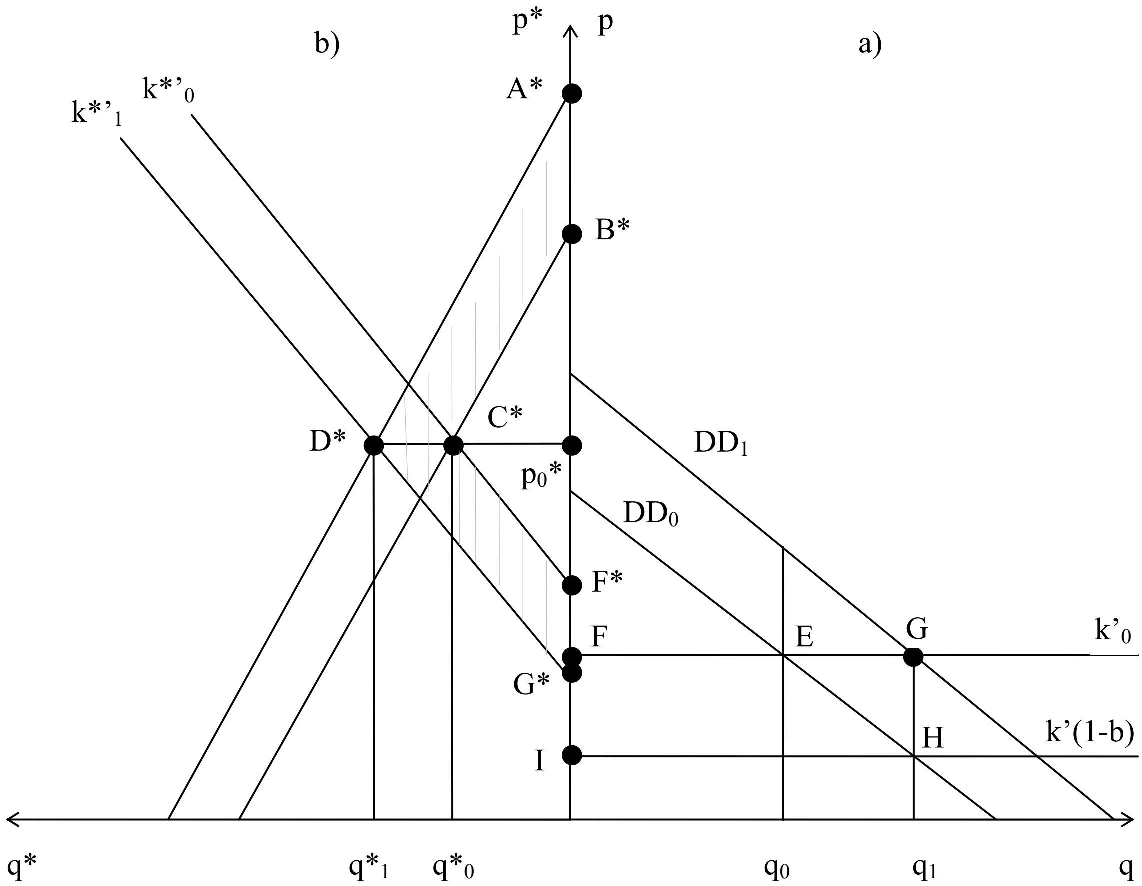
Figure 6: R&D Promotion, Production and Trade



2.3.2. Intermediate Traded Products, R&D Subsidies and Rent-Shifting

Another neglected field of R&D promotion in open economies concerns the case of an intermediate technology-intensive product produced in country I and exported as an intermediate input to country II. We will subsequently consider the case of traded intermediate product innovations whose use in country II raises the marginal willingness in the market for the final product. Assume that the government in country I offers R&D subsidies, largely reflecting thereby the positive external effects in country II, so that q_1 of the intermediate product is produced in country I instead of the natural market solution, q_0. R&D subsidization allows for the production of a higher quality of the intermediate product so that the demand curve for the final product shifts outward in country II. As intermediate products are obtained at subsidized costs from producers in country I, we have a downward shift of the k* curve abroad (see panel b). The positive welfare effect accruing for country II is given by the area A*B*C*F*G*D*. However, the costs of R&D subsidies in country I are equivalent to the area FGHI.

Figure 7: International External Effects of Domestic R&D Promotion (Technology-intensive Inputs for Tradable Products)



Under which conditions would country I be interested in providing an R&D subsidy for an intermediate product when the main welfare effect is observed abroad (as shown in our simple partial equilibrium model in the above figure)?

- (i) If country II could offer country I an adequate share in income taxes as a compensation for the R&D costs.
- (ii) If the firms in country II are largely owned by residents of country I – at least with respect to higher profits in country II (sent to country I as profit remittances), there is effective taxation in country I; the profit increase in country II is equivalent to the area, C*F*G*D*.
- (iii) If a large share of demand abroad effectively represents users from country I (e.g., in the case of tourism or in the case of mobile internet services).
- (iv) If there are positive effects not only for country II but also for other sectors in country I so that part of the shift from DD_0 to DD_1 represents domestic positive external effects. The latter could explain why Korea subsidizes R&D in Boeing, intermediate inputs manufactured in Korea.

In the EU-25 single market where technology-intensive intermediate inputs are partly produced in EU countries catching-up, there are indeed arguments that rich countries which dominate the final assembly of technology intensive products should transfer an adequate share of income taxes to those countries which deliver intermediate products developed on the basis of R&D subsidies in the respective country. Since one may assume that this typically concerns cases in industry and that the main producers of technology intensive final products are Germany, France, Sweden, Finland and the Netherlands, we have a new argument that these countries contribute over-proportionately to the EU budget. It is, however, unclear that countries producing much technology intensive intermediate inputs really obtain an adequate share of EU transfers. So far, the EU transfer scheme does not consider the case of technology-intensive intermediate products.

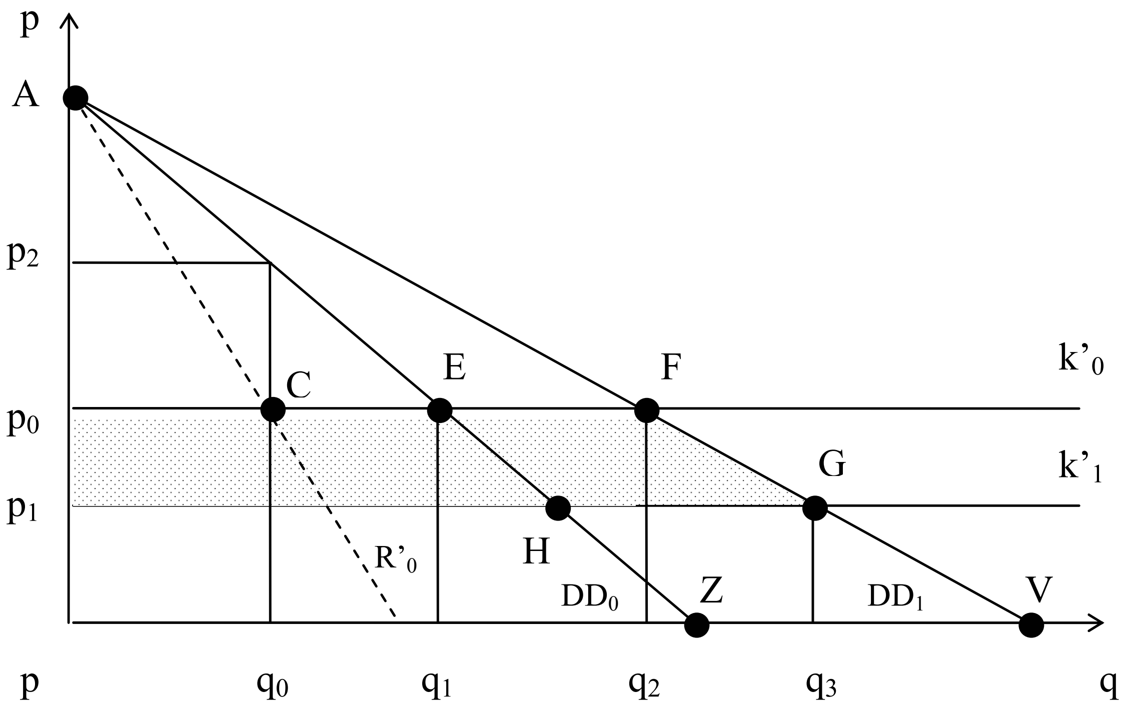
In a more general sense, the existence of the single EU market and the ongoing globalization imply that there could be an increasing role of the internationalization of R&D, including the production of innovative intermediate products. This internationalization of R&D and the associated positive international external effects could imply that all governments spend less on R&D than would be optimal. The simple reason for this is that an international tax revenue sharing scheme has not yet been developed by the OECD. (As the basis for such a scheme, one would have to analyze the size and direction of technology spillovers, which could be quite cumbersome).

2.3.3. Network Effects

In the digital economy, there are more fields with network effects than in the traditional industrial economy. Network effects can be understood as an endogenous outward rotation of the demand curve (alternatively, as a rightward shift of the demand curve) in the process of network expansion. For example, the marginal utility of having access to the telephone network will increase for the initial users if more users – read potential communication partners – are switched on the network, at least as long there are no additional congestion costs. This is also the case for advanced software and novel internet services. A monopolistic supplier facing the demand curve DD_o would impose under the standard Cournot monopoly solution the monopoly price p_2 which goes along with output q_0. For simplicity, we assume that a conservative monopoly firm would neither be willing nor able to exploit network effects, that is, to anticipate that the dynamic demand curve – including network effects – is DD_2 and not DD_1. If government offered a one-off R&D subsidy for process innovations (shifting the marginal costs curve from k'_0 to k'_1) to several firms under the condition that network effects be jointly exploited, the conditional competitive solution would be point G.

The positive welfare effect from the network effect is the area AEF plus the effect seen by cost cutting, namely EFGH. An additional welfare benefit – not related to network effects – would come in the form of the area p_0EHp_1. Thus, network effects represent a neglected and interesting field of R&D subsidies (for a broader partial equilibrium analysis, also see appendix 2).

Figure 8: Network Effects and Cost-Saving Progress

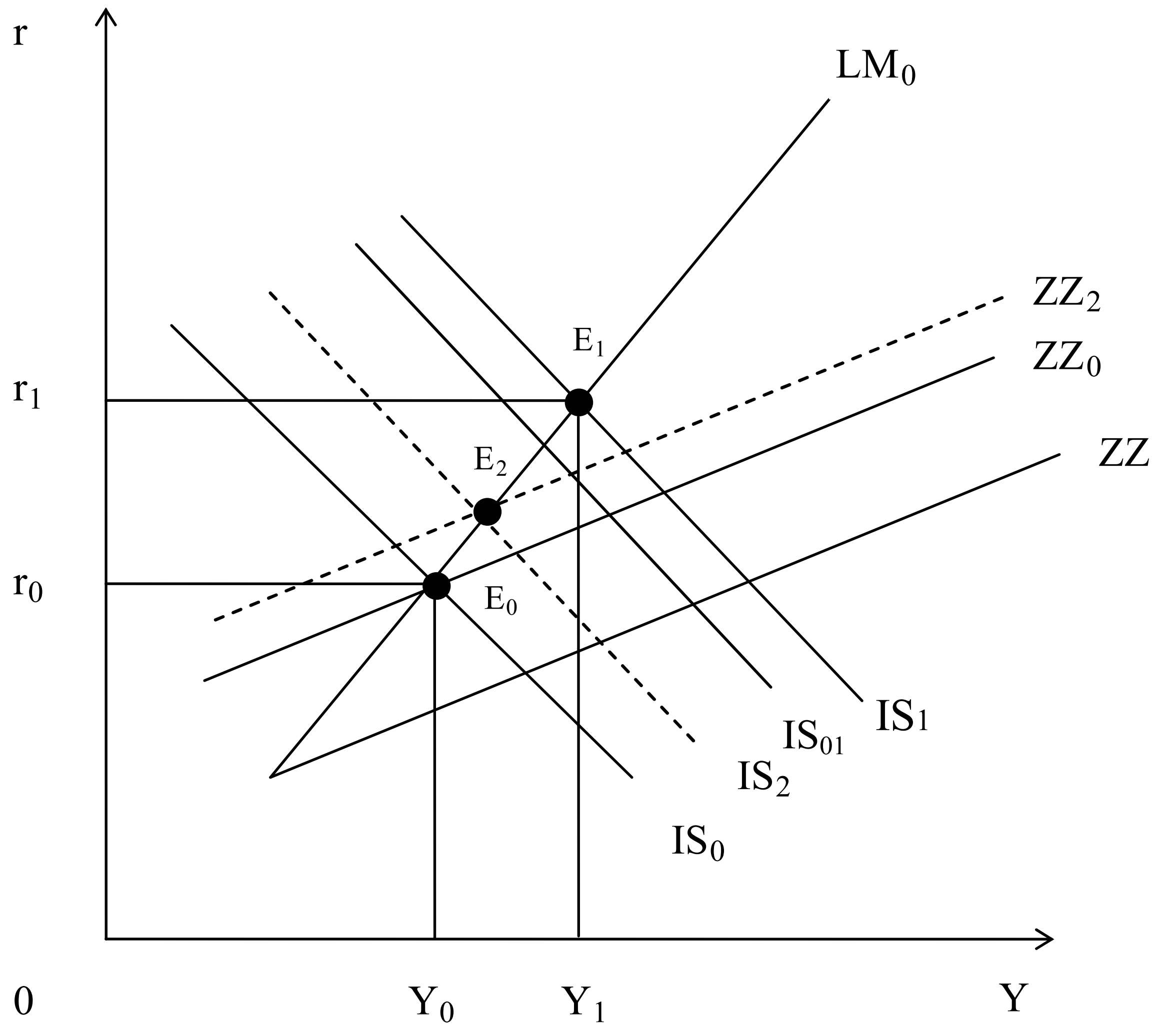


2.3.4. Macroeconomic Approach: A Schumpter-Mundell-Flemming Model

The familiar Mundell Fleming model suggests that fiscal policy is effective under fixed exchange rates, while monetary policy is ineffective. Under flexible exchange rates, it is monetary policy which is effective while fiscal policy is relatively ineffective. In the following analysis, we suggest that supply-side oriented fiscal policy – namely raising R&D expenditures in order to promote product innovations – can have positive effects on output and employment within the framework of an extended model. The basic arguments have been presented in WELFENS (2004), where a key idea is that consumption C, investment I and (net) exports X positively depend on product innovations v. In reality, a higher export unit value could be obtained due to product innovations, and the quantity shipped abroad might increase as well. The larger the tradables sector affected relative to the overall economy, the larger the effect on net exports of goods and services.

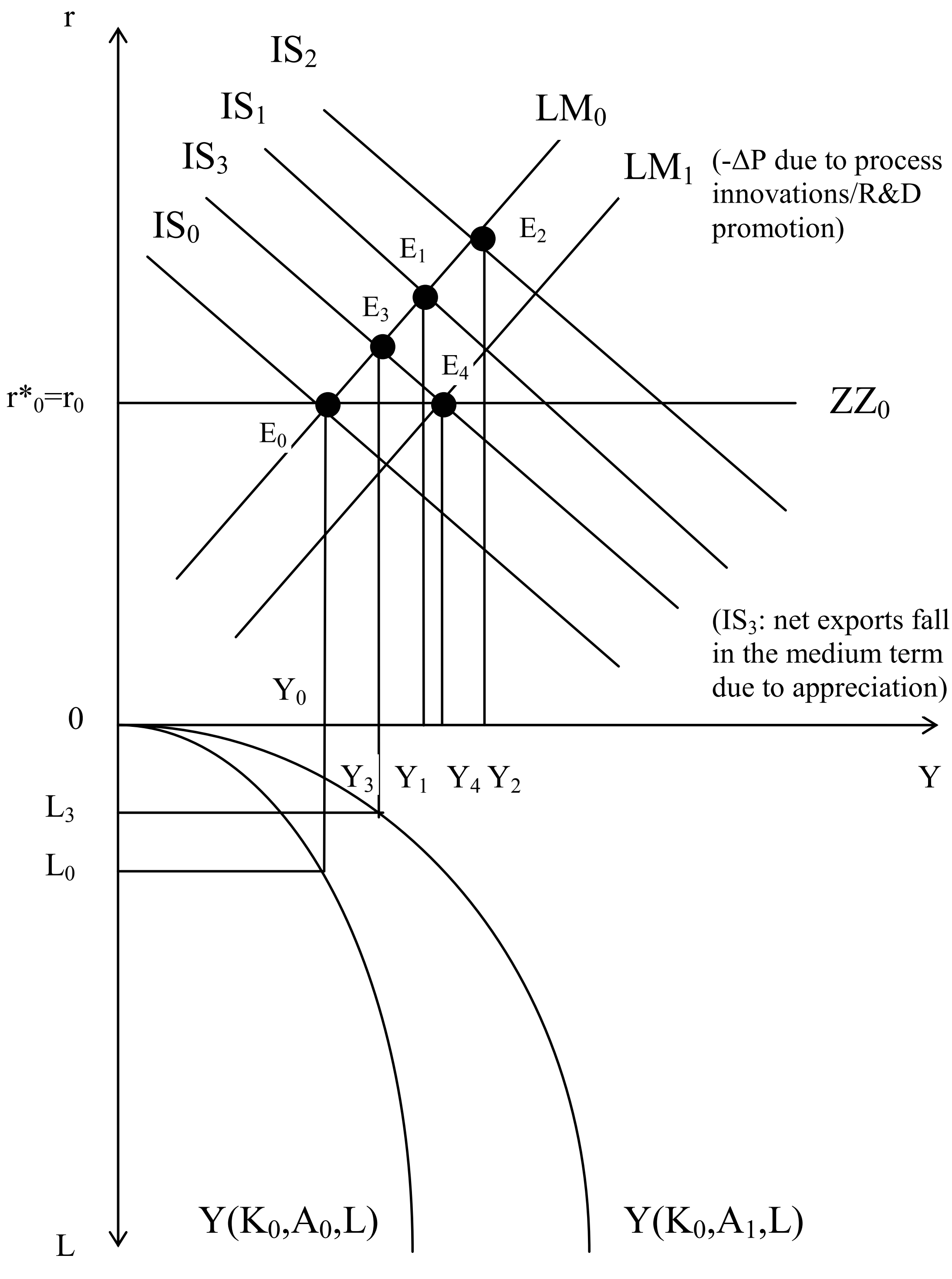
Through an innovation-promoting fiscal policy – with a focus on product innovations –, we basically get a rightward initial shift of the IS curve since government R&D expenditures and hence aggregate demand increase. In the medium term, we get more product innovations v so that investment and consumption increase; net exports also increase. While the ensuing real appreciation of the currency dampens the net export effect (the IS curve shifts back to the left, while the balance of payments equilibrium curve ZZ shifts upwards), the overall effect on output and employment is favourable as is shown in the following graph. A minor complication in a model with product innovation is that in applying the logic of hedonic pricing, we implicitly get a fall of the price level, thereby shifting the LM curve to the right (not shown in the graph). There also is the potential problem of considerable time lags. Higher R&D promotion could translate into more product innovations only after several years. However, as investors will anticipate this effect, improved profit expectations should already stimulate output after a short period. From a policy perspective, there could also be a problem stemming from strategic R&D behaviour of firms which cut R&D expenditures more strongly in recessions with the hope that government R&D support will effectively allow for the substitution of company funds through governmental subsidies. Government could cope with this problem by using an adequate base year.

Figure 9: Expansionary Fiscal Policy Promoting Product Innovations



If government raises R&D expenditures in order to promote process innovations, we get a less favourable result to the extent that technological progress is labor-saving. Labor in efficiency units is AL and the production function is Y (K,AL), where Y is output, L is labor, and K is capital. Depending on the strength of the upward shift of the production function, labor-saving technological progress might indeed lead to a new equilibrium in which the demand for workers is lower than initially the case. There are less jobs available than in the initial equilibrium ($L_3 < L_0$: see graph).

Figure 10: Expansionary Fiscal Policy with a Focus on Promoting Process Innovations



In the above model setting, we have assumed that net capital imports Q=Q(i,i*,v,q*), where v is the rate of product innovations, raises profitability and hence foreign direct investment inflows. The impact of the domestic and foreign interest rate i and i*, respectively, requires no further comment. Not so apparent is the positive impact of q*=eP*/P (e is the nominal exchange rate, P and P* the domestic and foreign price level, respectively). The link is explained by the FROOT-STEIN argument, which emphasizes the role of imperfect capital markets for foreign direct investment inflows. The ZZ line has a slope of zero if the interest elasticity of capital flows ($\partial Q/\partial i$) is infinite.

Note that the balance of payments equilibrium line (ZZ) does not only have a slope of zero when the interest elasticity of capital inflows is infinite; it could also have a slope of zero if we assume – a realistic case in view of empirically significant gravity equations of foreign direct investment – a net capital import function Q(i,i*,v,Y,Y*), where the partial derivative $\partial Q/\partial Y$ is positive. Both $\partial Q/\partial Y$ and $\partial Q/\partial Y^*$ reflect the impact of domestic and foreign output on net foreign direct investment inflows on net foreign direct investment inflows. If$\partial Q/\partial Y$ is equal to $\partial J/\partial Y$ – with $\partial J/\partial Y$ denoting the marginal propensity to import goods –, the slope of the ZZ curve is zero, even if the interest elasticity of capital mobility is low. In the case of poor countries opening up to trade and foreign direct investment – e.g., in the case of Newly Industrializing Countries or post-socialist transition countries – the marginal propensity to import will at first increase. After some time, $\partial Q/\partial Y$ will increase and the special case $\partial Q/\partial Y = \partial J/\partial Y$ could occur and hold for some time, thus leading to an interesting empirical question..

2.3.5. Empirical Insights from the Analysis of Innovation, Growth and Structural Change

Recent empirical analysis (JUNGMITTAG, 2004) shows that a macroeconomic production function is useful in which not only labor, capital and technology enter into play, but also the degree of economic specialization in high technology products. An alternative specification in which specialization as such – Smithian specialization – matters did not yield significant results for the production function. We assume that the pressure to specialize more strongly in technology intensive products is reinforced if there is increasing import competition of countries which are catching up technologically (e.g. as measured by R&D input indicators or R&D export indicators). According to this line of reasoning, measures to liberalize trade could have long term benefits in terms of both higher per capita income and higher growth rates.

In the context of EU Eastern enlargement, it was shown (BORBELY, 2004) that accession countries have specialized in different ways while also recording specific performance with respect to the development of export unit values. Hungary and the Czech Republic recorded positive RCA dynamics in both medium technology intensive products and in selected high technology sectors. Moreover, in some sectors, improvements in export unit values were recorded in the decade after the early transition recession. This ability to move up the technology ladder and to obtain higher prices in world markets might be strongly related to foreign direct investment inflows.

3. Policy Conclusions

3.1 General Policy Conclusions for Innovation Policy in Open Economies

In open economies, there is some risk that R&D promotion is smaller than would be optimal under global welfare considerations. If there are symmetric international R&D spillover effects, one would have little reason to wonder about optimum R&D support. However, reality is likely to show asymmetric positive international external effects since countries trading with each other have different technology levels and since the degree of openness and trade in intermediate technology intensive products differs across countries. Obviously, it would be useful for countries with high technology-intensive tradables output to cooperate in

R&D policies which might include international tax revenue sharing. Assuming that the difference between private and social benefits of innovation is even larger at the level of the world economy than at the national level, one may raise the question of whether the internationalization of business has not brought about an increased divergence between existing and optimum R&D subsidies. (While the EU might be considered a supranational player in R&D promotion, one must point out that the share of R&D promotion in the budget is very small and that the current transfer system is not rewarding countries which support R&D in firms which produce technology intensive intermediate products.)

Innovation systems differ across countries. However, some key ingredients can be identified: There are public R&D funds and there are private R&D funds, whereby the latter typically has a focus on applied R&D while the former emphasizes basic research. Funds have to be partly invested in R&D facilities. At the same time, hiring highly skilled workers and dynamic researchers is crucial for high innovation performance. Skilled workers represent tacit knowledge, which often make international relocation of R&D intensive production difficult. In addition to this, a modern education system as well as the import of technology intensive imports and government R&D promotion must be considered. This should then result in sustained innovation dynamics and growth of output and employment.

Countries have specialized in certain technology intensive fields which typically show a positive RCA over time. Facing economic globalization and intensified global competition, it makes sense for governments to focus their R&D support within internationally-competitive sectors. This seems to be even more the case the larger the backward linkages and forward linkages are and the larger the respective sector is itself. Such a strategy of supporting existing fields of comparative advantage and also fields of rising export unit value would, however, leave open the question to which extent relatively new sectors – such as nanotechnology or biotechnology or information & communication technology – should be supported. Obviously, it is useful to support such sectors to the extent that the respective country is richly endowed with complementary human capital and that the capital markets encourage creation of technology-intensive innovative start-up companies. (In the field of digital services, Germany faces particular problems since the dominance of banks and the relative weakness of venture capital funds impairs the creation and expansion of firms which offer little collateral.)

3.2 Specific Policy Conclusions for Germany

3.2.1 R&D Promotion for Medium Technologies and High-tech Industry

Germany's traditional strength is in medium intensive technologies such as automobiles, machinery and equipment. The government should continue to encourage R&D in medium intensive technologies, provided there are good arguments in favour of positive external effects. There are long established cooperations between universities and firms in the automotive industry and in the capital goods sector. However, one might want to broaden cooperation across borders and also internationalize the German university system in a way that teaching and conducting research abroad would be a normal element of a long term strategy of achieving excellence in research and teaching and of creating networks allowing for the finance of innovative projects in both teaching and research. As regards international activities of German universities, there are only a few exceptions. State-owned universities would find all kind of bureaucratic barriers if they wanted to expand internationally. Thus, privatizing several universities and giving more autonomy to universities would be highly desirable, but in the political arena no such initiatives have been adopted.

Given the medium term technological catching-up of EU accession countries in Eastern Europe and of Asian and some Latin American countries, the high wage economy of Germany would be well-advised to increasingly specialize in knowledge intensive and technology intensive sectors; this should include high technology sectors. Germany must move up the technology ladder and undertake serious efforts to modernize the education system accordingly. There have been very few efforts in the field of modernizing the education system. The PISA shock which saw bad results for Germany has encouraged some reforms in basic schooling. However, there are few efforts to really modernize the education system on a broader basis. Such commitment could be visible with the creation of new universities, tax incentives for the creation of private universities and tax incentives for adults to engage in advanced training and retraining. Such measures have not been undertaken thus far in Germany. One should also note that Germany, with its ageing society, could face a long term decline in output growth unless the rate of technological progress and the quality of human capital formation are improved in a sustained way. Short-sighted politicians are also sometimes inclined to impair innovativeness simply to get additional short term revenues. (A prime example in this respect involves the Ministry of Health, which forced leading pharmaceutical companies to pay an extra lump sum tax as a contribution aimed at alleviating the funding problems of the health care system. Such a policy is a wonderful starter for gradually killing the once globally leading German pharmaceutical firms. At the bottom line, the government obtained a few hundred million Euros yet thereby undermined innovation dynamics worth billions of Euros).

3.2.2 Skill upgrading and Reform of the Education System

Facing economic and technological catching-up in Eastern Europe, Russia, Asia and Latin America (plus a few countries in Africa), the German economy will have to increasingly emphasize the production of technology-intensive and skill-intensive or knowledge-intensive products. More training and retraining as well as the modernization of the basic education system are major challenges for Germany. As regards incentives for firms and employers to engage more in training and retraining/skill-upgrading, the government could introduce adequate conditional tax benefits. Given Germany's budget problems, higher expenditures or reductions in tax revenues are only acceptable if new sources of tax revenue become available. Since Germany has a very low VAT rate among EU countries, one could consider raising the VAT rate as a means to finance incentives for the training, retraining and modernization of the education system.

As regards the university system, it would be useful to not only step up competition among universities but also to encourage foreign universities to set up satellite centers in Germany. A broader and more international supply side in the academic system would be quite useful not only for Germany but for other EU countries as well. A major weakness of the German university system is the low share of female graduates in engineering and informatics. The low share of female graduate in informatics (abut 15% at the beginning of the 21st century) is a serious disadvantage for a country which is facing an ageing of its society in the long run and modest economic growth in the short term. The US and many countries in the EU have been relatively successful in raising the share of female graduates and in encouraging a high share of female entrepreneurship. Germany has a long way to go in this respect.

3.2.3 Problems with Immigration of Unskilled Labour

The specific unemployment rate of unskilled workers was roughly twice the national average. Among immigrant workers, the specific unemployment rate is even higher. This poor result is partly due to the weakness of the German schooling system at successfully integrating foreigners. Since foreign workers have below average skills, it is not surprising that they become unemployed more often than workers born in Germany. The situation in Sweden (and some other EU countries) is different. Sweden in particular has emphasized and facilitated the immigration of skilled workers.

The free movement of labour has been restricted in the enlarged EU-25 until 2011 (at the latest). Germany is likely to attract a high degree of unskilled labour after 2011, since youth unemployment and overall unemployment rates in many accession countries of Eastern Europe are high. Economic geography – Germany's proximity to the accession countries – and economic incentives, namely high German wage rates and low social integration costs due to a large stock of foreigners (from eastern Europe) from previous immigration waves, make Germany a natural target country for those wishing to emigrate from eastern Europe. Such immigration will include citizens from Bulgaria and Romania, where relative per capita income (at purchasing power parity relative to EU-15) was only about 22% in 2003.

If the EU were to seriously consider Turkish membership, one would have to anticipate a large wave of additional Turkish immigrants in the future. The population in Turkey is growing at a pace of about 1 million per year, with the population growing from roughly 70 million in 2004 to 120 million by 2050. The high wage economy of Germany would thus face millions of Turkish immigrants once Turkey – with a per capita income of about 20% of EU-15 average in 2003 – enjoys full membership. Immigrants from Turkey would be largely unskilled workers which would reinforce unemployment problems in Germany. Against this background, it is doubtful that German politicians would quickly embrace EU membership for Turkey. If EU leaders were to quickly move towards EU membership, this might signal an integration overstretch, which could even result in a future German government leaving the EU under the heading "we want control of immigration, want to save funds used inefficiently by the EU and prefer having the D-Mark again." One should remember that the very purpose of creating the EU in 1957 was to firmly anchor the Federal Republic of Germany in Western Europe, and it would be historically tragic if enlargement to include Turkey drove Germany out of the Community (in the accession year 2004, the EU is hardly able to work effectively since there are so many new politicians and inexperienced bureaucrats in Brussels).

3.2.4 Improving Knowledge Transfer from University to the Business Community

Traditionally, there have been close links between firms and universities in Germany. However, universities have been relatively reluctant to promote early entrepreneurship of graduates. Moreover, many public universities are highly inflexible, bureaucratic and reluctant with respect to innovation and internationalization. Incentives to improve knowledge transfer from the university system to the business community would be much stronger if half of the universities were private universities which were more competitive in acquiring research funds from industry and public institutions. Privatizing a considerable number of universities and attracting foreign private universities could be interesting policy options to accelerate knowledge transfer.

The existing transfer institutions are rather bureaucratic and slow, the incentives from the slow marketing of patents obtained by professors at the universities are weak. While the three leading US universities had revenues of about 15% from patents and licensing at the beginning of the 21st century, the leading German universities had a revenue share in this category of not more than 2%.

While the links between the university and large MNCs in Germany are well established, such networking hardly exists with respect to most SMEs. Here, the internet offers new platforms and opportunities. However, local telecommunications is relatively expensive in Germany, not least due to the quasi-monopoly which the Deutsche Telekom AG (still largely government-owned) has maintained in traditional fixed-line telecommunications. Moreover, the German government allowed Deutsche Telekom AG to establish a dominant market position in the DSL market with the market share of the state-owned firm having been close to 90% in 2003. Germany cannot really deliver an optimum contribution to the Lisbon process if government does not strongly promote competition in both fixed-line telecommunications and the DSL market. DSL competition in France is much stronger than in Germany, and consequently France has overtaken Germany in terms of the absolute number of DSL lines in late 2004 when France reached a level of about 5 million lines. The share of households with broadband internet connection was close to 30% in Belgium, Denmark and the Netherlands (largely due to cable TV) in early 2004. In Sweden, Finland and Austria, it was in the range of 15-20%. Spain, France and Portugal had close to 15%, while Italy, the UK and Germany had only 12-13%. From this perspective, neither Italy, the UK nor Germany currently have an ideal starting point for developing and marketing innovative digital services. However, large countries always enjoy the benefit of a large home market.

3.2.5 Keeping Skilled Workers and Innovation Leadership in the Region

Facing the new international division of labour in Europe and worldwide, it is obvious that a high wage country such as Germany should specialize more on producing knowledge intensive and technology intensive goods and services. Advanced services seem to be particularly underrepresented in Germany with part of the problem being a lack of competition in retail banking, telecommunications and energy. These sectors have been sheltered from international competition for many years, and productivity growth has been relatively slow except for the post-1998 period in fixed-line telecommunications. Universities should be encouraged to focus more on these potentially dynamic liberalized sectors.

At the same time, regional government or national government could provide tax incentives for venture capital funds set up by large companies in these sectors (and other sectors). A rising share of venture capital funds should go to young firms created by university graduates. Regional government could provide R&D facilities and modern infrastructure for young technology oriented firms centred around a business park. Regional governments would be wise to promote existing clusters of excellence as well as new dynamic fields with growing long-term demand and a high rate of technological progress. Regional government can try to keep potentially mobile innovative companies in the respective region by offering generously modern facilities for innovators. Promoting innovative supplier clusters is also an option to reduce the mobility of innovators. An important ingredient in gluing innovative companies to a region is a network of highly innovative and flexible universities and R&D labs. Germany faces major financial problems in university and public research funding, and this could become a serious impediment for implementing adequate policy priorities.

3.2.6 A European Policy Perspective

Germany would be wise to embrace the best-practice approaches of other EU countries. Among the interesting new developments are open innovation systems such as the R&D park in Eindhoven where Philips is the leader in a large network of innovative firms. Cross-licensing is a typical element of networking in this R&D park. A major strategic goal of Philips is to nurture international R&D networking in a way that helps to set global standards quickly. Revenues from international licences increasingly contributed to Philips' revenue in the 1990s and in the beginning of the 21st century.

As industry becomes increasingly mobile in the EU-25 and as accession countries catch up over time, it is natural that research activities also become more footloose. In a dynamic open economy, nobody should expect to easily earn high income in traditional fields of specialization. Rather, it will be necessary to react relatively flexibly and to move into new markets and niches. For firms, the challenge is to develop flexible, efficient and innovative-enhancing structures. For national policymakers and the EU, the medium-term challenge is to shift the focus of R&D policy more towards success-promising new fields. Both the national and the supranational policy level should become more efficient and effective in R&D promotion. Moreover, at both the national and the supranational level, a strong emphasis on competition and open markets is essential. While better digital intellectual property rights seem to be necessary in general, the special case of software patenting raises serious doubts. In a sector in which network effects automatically become an endogenous barrier for market entry, software patents are quite doubtful. It is true that the software market is not homogenous, but easy patenting of software should certainly be avoided if the policy goal is to encourage digital innovations in the long run.

One should take the Lisbon process seriously in all EU member countries, in particular in large Eurozone countries such as Germany, France and Italy. There is little doubt that Germany and Italy have underestimated the challenges of achieving sustained growth for many years. The heated public debate of 2003/04 between politicians and researchers in France – the latter pointing out a massive funding gap for top R&D institutions and projects – shows that not only Germany (or Italy) has serious problems in allocating sufficient funding to promoting innovations. Regular monitoring of national and regional R&D policies could be quite useful in generating more pressure on member states to adopt efficient R&D policies and to increase spending on innovation and human capital formation.

Appendix 1: Optimum Product Innovation under Uncertainty

As regards innovation efforts, firms can undertake R&D at fixed costs H, where one may assume that the probability to obtain a (temporary) monopoly depends on H. Let us assume that without product innovations we have a linear demand function $p = a - bq$; we assume that R&D costs H reflect efforts in product innovations which raise the willingness to pay, so that denoting α as the parameter to indicate the rise in the willingness to pay for innovative products and α as the probability of successful innovation, the expected demand function in the case of a product innovation is:

(7a) $p = a + \alpha(H) - bq$

Here α is the probability to successfully launch a product innovation and thus also the probability to obtain a monopoly provided that competitors are expected to remain passive as is assumed here. Production costs are assumed to be proportionate to q and to include R&D costs which are fixed costs H (an alternative would be to assume that R&D costs for product innovations are equal to $H + [n / q]$):

(7b) $Z = hq + H$

Under standard competition, the market is characterized with $p = h$ and $q = (a - h)/b$; standard monopoly theory suggests a monopoly quantity $q^M = (a - h)/2b$ and monopoly price $p^M = (h + a)/2$.

Denoting α as the probability of a successful product innovation, r' as the revenue under monopoly, R^C under competition, R^E as expected revenue and Q as profit we assume that the firms wants to maximize the profit function:

(8) $Q = R^E Z = \{a(H)r' + [1 - \alpha(H)R^C]\} - [hq + H]$

Expected revenue in our approach is:

(9) $R^E = \alpha(H)[aq + \alpha(H)q - bq^2] + [1 - \alpha(H)][aq - bq^2] = [aq - bq^2] + \{\alpha^2(H)q\}$

The term {…} makes the difference to the standard approach in profit maximization. The monopolist will equal marginal production costs $k'(q)$ and marginal expected revenue $R^{E'}$ which is

(10) $R^{E'} = a - 2bq + 2\alpha(H)$

Optimum output is given by $h = R^{E'}$ and therefore:

(11) $g\# = [a - h + 2\alpha(H)]/2b$

The corresponding price is – enforceable in the case of successful product innovation is:

(12) $p\# = a + \alpha(H) - b[a - h + 2\alpha(H)]/2b$

Compared to standard monopoly theory, the approach presented shows a marginal revenue which is higher so that optimum output in a Schumpeterian economy will indeed be higher in every market with product innovations than in a noninnovative economy. The optimum H can be determined from $dV7dH = 0$, which yields:

(13) $Q = [aq - bq^2] + \{\alpha^2(H)q\} - [hq + H]$

(14) $\partial Q / \partial H = 0$

(15) $2\alpha(H)\alpha_H q = 1$

Inserting optimum q implies:

(16) $2\alpha(H)\alpha_H[a-h+2\alpha(H)]/2b=1$

Denoting the elasticity of α with respect to H as $E_{\alpha,H}$ we can write

(17) $2(1/H)E_{\alpha,H}[a-h+2\alpha(H)]/2b=1$

Implicitly from this function, the optimum H can be derived. Note that the optimum H – which is a fixed cost here – must be below the expected profit from product innovation, because the firm is otherwise squeezed out from the market. One should also note that the market will be characterized by excess capacity if the product innovation cannot be launched successfully. The reason for a tendency to overcapacity in the market is that the firm will decide about optimum q in advance. If the product innovation cannot be launched successfully, the firm can still cut back production – and hence avoid marginal costs of initially-planned production – in a way that excess production in the market is avoided. Finally, it should be noted that in innovative sectors temporary excess capacity should not be identified with signs of a recession since it simply is a by-product of product innovation under uncertainty. If a rise of per capita income goes along with a rising degree of product differentiation and hence a stronger tendency towards product innovation the problem of apparent excess capacity in the overall economy could gradually become more important during certain periods. If government promotes product innovation, an unwelcome by-product could be temporary excess capacity in some sectors. Moreover, government measures to promote growth (raising per capita income) could indirectly stimulate product innovations and hence bring about the problem of temporarily idle capacities. In an open economy, such excess capacity might lead to unplanned net exports in the respective sector. If the exporting country is large, this will entail a temporary reduction of world market prices.

Appendix 2: Product Innovations and Network Effects in a Simple Model

Assume that willingness to pay depends on the degree of product innovation V, which in turn is proportionate to innovation efforts H, while production costs positively depend both on the quantity produced q and the innovation efforts H. In the following simple model, we will look at some interesting aspects of product innovations in sectors with network effects. We will consider the behaviour of an experienced innovator who is certain that innovation expenditures on product innovation will translate into a temporary monopoly position. For simplicity, we assume $V=H$ and that the demand function is $q=H^{\alpha'}a/p$ (where α and α' are positive parameters; and by assumption $\alpha'>0$. Note E_{yx} will denote the elasticity of variable y with respect to variable x). Note that such a demand function implies that revenue is constant since $R=pq=H^{\alpha'}a$

Thus for the profit maximizing firm undertaking product innovations, we the following expressions for the demand function function and for profit Q, respectively:

(18) $q=H^{\alpha'}a/p$

(19) $Q=p(H)q-k(q,H)$

Maximization of this function requires in a competitive framework:

(20) $dO / dq = p - k'(q, H) = 0$

Hence

(20a) $p = k'(q, H)$ under competition **(a minor problem occurs with maximization due to the constancy of revenue for any given H !)**

(20b) $R'(q, H) = k'(q, H)$ **under monopoly;** with revenue $R = p(q, H)q$

and

(21) $dO / dH = \partial p / \partial Hq - \partial k / \partial H = 0$

Inserting the demand function we have:

(22) $\partial p / \partial HH^{\alpha'} a / p = \partial k / \partial H$

(23) $E_{p,H} H^{\alpha' - 1} a = \partial k / \partial H$

Hence the optimum product innovation effort H# is given by the necessary condition

(24) $H\# = \{[\partial k / \partial H] / aE_{p,H}\}^{1/1-\alpha'}$

After choice of $H\#$, the firm can choose output q in a way that the condition marginal revenue equals marginal costs is fulfilled. According to the above equation, the product innovation effort will be the higher the lower the marginal costs of innovation $\partial k / \partial H$ and the lower the elasticity $E_{p,h}$ of the price with respect to innovation (efforts) and the lower the basic willingness to pay as expressed by a is.

How will network effects affect the elasticity of p with respect to H? If the market is characterized by network effects, we may assume that the elasticity of p with respect to product innovation effort H is lower than in a normal market (this effect could be estimated empirically), because network effects stimulate competition which in turn drives down the market price. Hence the optimum product innovation effort would be higher – every round of product innovation is a new starting point to escape the move towards low competitive prices. At the same time, there could be scale effects whose exploitation is facilitated in the presence of network effects. If there is only one firm, it should be easy to anticipate the positive network effect. However, the firm will charge not only a temporary monopoly price – which is a natural side-effect of the product innovation itself – but it will charge a monopolistic price even in the long run; it also will adopt a lower rate of product innovation. With many firms in the market, the firm which launches a product innovation only has a temporary monopoly. As soon as there is broad imitation, the innovating firm can no longer fetch a monopoly price in the market. It must accept a price which is equal to long-term marginal costs (assumed to be constant in the subsequent graph where we show an initial monopoly price plus a situation with a product innovation in the context of monopoly pricing as an analytical starting point).

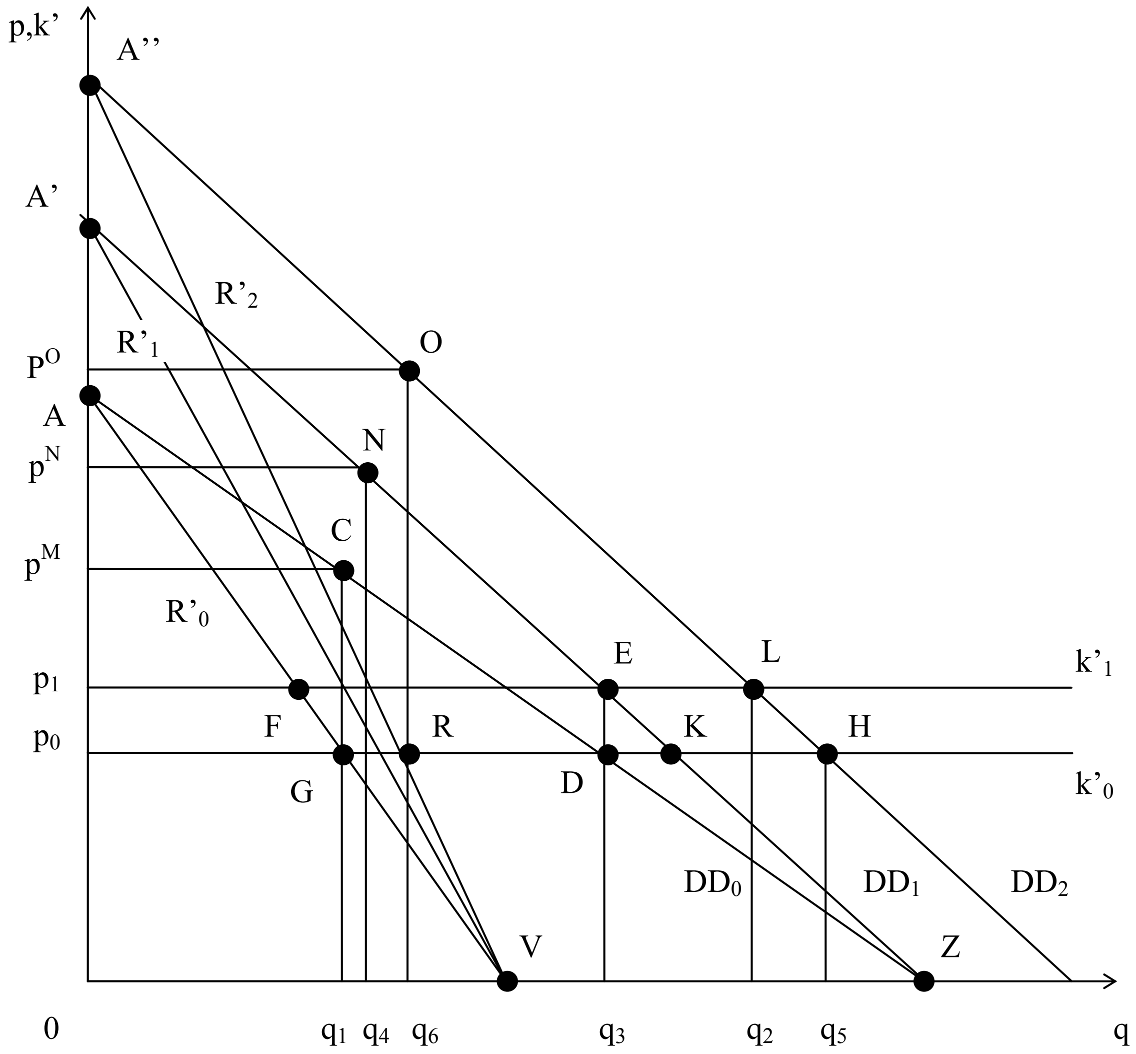
If there are quasi-scale economies in the sector considered, the marginal costs of product innovation will be negatively influenced by the size of the market, which in turn is positively affected by network effects. The latter thus bring about a positive external costs effect for all competitors. The assumption that network effects reduce the marginal costs of innovation can be justified only if the size of the market is a positive signal for attracting more researchers to R&D activities in which learning by doing or intra-sector spillovers plays a role. Note that under monopoly, we have price p^N for the product innovation both in the short term and in the long term, but under competition, it would be the lower price p_1 in the long run. Hence government should encourage competition and help high barriers to entry from occurring.

Endogenous barriers resulting from strong network effects in industry (e.g., in the software sector) could also be a problem which would not always justify standard patent protection.

Our line of reasoning can also be seen form the following graph where we show an initial marginal costs curve k'_0 and a new marginal cost curve k'_1 which is relevant in the context of the product innovation. The initial equilibrium point under monopoly and the initial demand schedule DD_0 is point C and hence output is q_1 and the monopoly price p_M. Now we turn to product innovation. There will be a rise of the cost curve stemming from product innovation efforts, and this reduces consumer welfare. At the same time, there will be an upward rotation of the demand curve (see DD_1) reflecting the increased willingness to pay for the novel product; the latter effect is associated with higher consumer welfare. A positive network effect is reflected in the graph as a rightward shift of the demand curve (see DD_2). If there are quasi-scale effects, there will also be a downward shift of the k' curve. For simplicity, we can assume that this shift effect fully offsets the initial shift from k'_0 to k'_1: Hence taking into account quasi-scale effects associated indirectly with network effects results in k'_0 so that the long-term competitive equilibrium is point H, output q_5 and price p_0 (without scale effects output would be q_2). Transitorily, there could be a monopoly situation with a monopoly price p_0 and output q_6.

There are cases when industry itself is able to exploit network effects fully (e.g., when leading firms in the sector agree on a new standard in the context of a product innovation). Setting standards in an environment of open interfaces of equipment allows for the exploitation of both network effects and scale effects. Modern electronics offers many examples of successful standard setting through industry itself. There are, however, well known examples of competing proprietary standards as well, as was the case with video recorders.

Figure 11: Product Innovation and Network Effects



Appendix 3:

NACE (EU classification) rev. 1.1 Classification at the 2-digit level (in parts)

D Manufacturing

15 Manufacture of food products and beverages

16 Manufacture of tobacco products

17 Manufacture of textiles

18 Manufacture of wearing apparel; dressing and dyeing of fur

19 Tanning and dressing of leather, manufacture of luggage, handbags, saddlery, harness and footwear

20 Manufacture of wood and of products of wood and cork, except furniture;

21 Manufacture of pulp, paper and paper products

22 Publishing, printing and reproduction of recorded media
23 Manufacture of coke, refined petroleum products and nuclear fuel
24 Manufacture of chemicals and chemical products
25 Manufacture of rubber and plastic products
26 Manufacture of other non-metallic mineral products
27 Manufacture of basic metals
28 Manufacture of fabricated metal products, except machinery and equipment
29 Manufacture of machinery and equipment n.e.c.
30 Manufacture of office machinery and computers
31 Manufacture of electrical machinery and apparatus n.e.c.
32 Manufacture of radio, television and communication equipment and apparatus
33 Manufacture of medical, precision and optical instruments, watches and clocks
34 Manufacture of motor vehicles, trailers and semi-trailers
35 Manufacture of other transport equipment
36 Manufacture of furniture, manufacturing n.e.c.
37 Recycling

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