

UNIVERSITY OF WUPPERTAL  
BERGISCHE UNIVERSITÄT WUPPERTAL

EUROPÄISCHE WIRTSCHAFT  
UND  
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**EU Eastern Enlargement and Structural Change: Specialization  
Patterns in Accession Countries and Economic Dynamics in the  
Single Market**

Prepared in the project "Changes in Industrial Competitiveness as a Factor of Integration: Identifying  
Challenges of the Enlarged Single European Market (Contract No. HPSE-CT-2002-00148)

Diskussionsbeitrag 106  
Discussion Paper 106

*Europäische Wirtschaft und Internationale Wirtschaftsbeziehungen  
European Economy and International Economic Relations*



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May 2003

*Herausgeber/Editor: Prof. Dr. Paul J.J. Welfens, Jean Monnet Chair in European  
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JEL classification: F10, F15, O30, O52

Key words: EU, Accession Countries, Structural Change, Trade, Technology



**Summary:** This paper analyses key issues of structural change and specialization patterns in the economies of an enlarged European Union. In all transition countries we observe a shift from the agricultural and industrial sector towards the service sector in terms of employment and productivity; however, in some countries a reindustrialisation drives is observed in a late transition stage. While some countries namely the Czech Republic, Hungary, Slovakia, Poland, Estonia and Slovenia, have improved their productivity especially in medium-technology-intensive industries and may advance on the technological ladder, others remain unchanged and seem to get locked in labour-intensive industrial sectors. In the context of EU-enlargement, we expect trade creation – going along with a rise of intra-industry trade – and higher FDI-activities. Countries will have to adjust along the logic of comparative advantage, however, technological upgrading and human capital formation are fields in which government can stimulate the direction of comparative advantage. According to the Gerschenkron-hypothesis the accession countries have an “advantage of backwardness. Since accession countries have a low R&D-GDP ratio in the early transition stage rising government expenditures on research and development plus higher education is crucial. We expect the EU-15 countries in general to benefit from enlargement but gains will be asymmetric across countries: economic geography matters. Austria, Germany, the Scandinavian countries, the Netherlands, Italy and France are likely to profit more than the other members of EU-15. Germany and Austria additionally play a particularly crucial role as origins of FDI. Future research should focus on the speed and the scope of structural adjustment.

**Zusammenfassung:** Der Beitrag untersucht Kernfragen des Strukturwandels und der Spezialisierungsmuster in den Volkswirtschaften der erweiterten Europäischen Union. In allen Transformationsländern wurden, gemessen an Beschäftigung und Produktivität, Verschiebungen von landwirtschaftlichen und industriellen Sektor hin zum Dienstleistungssektor beobachtet – z.T. mit späteren Reindustrialisierungsphasen. Während einige Ländern, insbesondere Tschechien, Ungarn, die Slowakei, Polen, Estland und Slowenien ihre Produktivität in mittleren technologieintensiven Bereichen verbessert haben und die Technologieleiter aufwärts steigen können, bleiben andere bei einer Struktur mit vielen arbeitsintensiven Zweigen. Im Kontext der EU-Erweiterung sind handels-schaffende Effekte – insbesondere in Verbindung mit einem Anstieg des intra-industriellen Handels – und verstärkte Direktinvestitionen zu erwarten. Alle beteiligten Länder müssen sich gemäß ihren komparativen Vorteilen spezialisieren, allerdings können staatliche F&E-Ausgaben sowie Bildungsanstrengungen auf die Entwicklung solcher Vorteile Einfluss nehmen. Die Gerschenkron-Hypothese postuliert für die Beitrittsländer einen „Vorteil der Rückständigkeit“. Da diese Länder in der ersten Transformationsphase niedrige F&E-Intensitäten in der ersten Transformationsphase aufweisen, ist die Modernisierung des Bildungs- und Forschungssektors wesentlich. Für die EU-15 als Ganzes wird ein Erweiterungsgewinn erwartet, aber die Vorteile werden sich über die Länder hinweg unterschiedlich darstellen, da die ökonomische Geografie eine Rolle spielt. Österreich, Deutschland, die skandinavischen Länder, die Niederlande, Italien und Frankreich werden voraussichtlich stärker von der Erweiterung profitieren als die anderen Mitglieder der EU-15. Deutschland und Österreich spielen zusätzlich eine wichtige Rolle als Ursprungsländer für Direktinvestitionen. Es gibt noch einen erheblichen Forschungsbedarf bezüglich Ausmaß und Richtung des Strukturwandels.



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*Prepared in the project “Changes in Industrial Competitiveness as a Factor of Integration: Identifying Challenges of the Enlarged Single European Market (Contract No. HPSE-CT-2002-00148)”*

## **EIIW Paper No. 106**

**May 2003**

# **EU Eastern Enlargement and Structural Change: Specialization Patterns in Accession Countries and Economic Dynamics in the Single Market**

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# 1. Introduction

EU eastern enlargement will eliminate all remaining protectionism in EU-25 and establish an area with a common legal framework and reinforce similarity of basic institutional conditions – e.g. democracy, independent central bank – in all member countries. In economic terms, EU eastern enlargement to some extent will be similar to southern EU enlargement as relatively poor countries will enter the existing community.

Intra-industrial trade can be expected to grow as accession countries will join the Community and benefit from both trade creation and sustained foreign direct investment (FDI), which is not only associated with capital accumulation but also with technology transfer. However, FDI inflows are unevenly distributed in transition countries; EU accession countries clearly can expect to benefit relatively strongly as compared to the former USSR and outsiders Romania and Bulgaria.

From an EU-15 perspective, eastern enlargement reinforces the dynamics of the single market for various reasons. The new single market volume for every tradable good will be larger than in EU-15 so that scale economies might be easier to exploit in EU-25. At the same time, intensified competition in the larger single market will force firms and countries to specialize more along the logic of comparative advantage. High-technology goods and some capital intensive goods will become more important in EU-15 countries, while production of low technology goods and standardized goods will often be relocated from Western Europe towards the accession countries. Part of our analytical approach is a Schumpeterian analysis in the sense that we emphasize technology intensity of goods, which also has been done in various studies in other works (e.g. KLODT, 1992; LANDESMANN, 2003; STEHRER/WÖRZ, 2002). HAVLIK (2002) has focused on key aspects of EU enlargement for Austria, HAVLIK/LANDESMANN/STEHRE (2001) have analyzed selected aspects of foreign trade specialization in transition countries and TRAISTARU/NIJKAMP/LONGHI (2002) and TRAISTARU/WOLFF (2002) have looked into regional specialization aspects and employment effects in accession countries.

Since wages are much lower in eastern European accession countries than in EU-15 countries, the logic of the Heckscher-Ohlin-Samuelson (HOS) theorem suggests that the Czech Republic, Poland and Hungary will witness a relative growth of labor intensive industries and respective exports. While this is partly obvious in some fields – e.g. textiles and leather – one must not overlook that the HOS theorem can be misleading to the extent that reality is not showing a two country world in which both countries have identical technologies. Hence one cannot rule out that Poland and Hungary would expand production of standard shoes on the basis of labor intensive production while Italy would maintain considerable shoe production on the basis of capital intensive production, with a strong emphasis on quality shoes and designer shoes with high prices. Hence there could be growing vertical intra-industrial trade within an enlarged EU.

To some extent, the eastern enlargement will create a larger single EU market with intensified competition in medium technology goods as firms in some EU accession countries will move upwards on the technology ladder. Since Poland, Hungary and the Czech Republic – plus Estonia and Slovenia – were leading recipient countries in FDI inflows in the first transition decade, there is considerable accumulation of capital and hence an increased production potential in medium technology tradables. This perspective is, however, not comprehensive, since the role of intermediate inputs also has to be taken into account. Based on an almost ideal demand system for imports from EU-12 countries from EU-South and CEECs at the disaggregated NACE level – differentiating between

final and intermediate goods – EGGER/KRATENA (2003) found that final goods imports are strongly complementary and intermediate goods are substitutive. Moreover, a rise in the high-skilled to low-skilled labor ratio in the EU-South or in the degree of intra-EU multinationality reduces competition (as measured by substitution elasticities) in intermediate goods trade between EU-South and the CEES.

It is not really surprising that a stronger EU-wide role of multinational companies reduces the degree of substitution since multinationals often organize production in the whole EU on the basis of strategic vertical integration across countries; or that rising MNC presence is associated with a larger role of ownership, specific technology advantages, and hence a rise in the level of technology intensity. Moreover, the higher the share of skilled labor, the higher the technology intensity. This at least is a hypothesis which one may state: and higher technology intensities go along with reduced own price elasticities and in most cases also with reduced substitution elasticities. Here, one may raise an important analytical objection to EGGER/KRATENA, since substitution elasticities can be used as a proxy for the degree of competition only at a given level of technology.

Adjustment dynamics in eastern European transition countries will reflect impulses from globalization, EU single market dynamics and domestic influences – including national policy measures. Globalization impulses will mainly come through trade with Asia, the US and Russia plus the Ukraine, and capital flows as well as trade impulses could play a role; as regards political influences, it will mainly be the impact of the US which considers the accession countries a political bridgehead to both the EU and Euroasia. EU influences will include all four channels reflecting the four freedoms of the single market – trade in goods, trade in services, capital flows, migration (after the maximum seven year transition period starting in 2004) and the stimulus of EU-15 economic growth plus impulses from the political EU layer which mainly means the impact from Community structural funds and special Interreg programs financing cross border cooperation among EU member countries. At the national level, budgetary policies in general and in particular subsidization, export promotion and R&D policies as well as state ownership in “residual sectors” will be crucial for structural change. Domestic policy influences could be rather volatile as most transition countries are characterized by a relatively weak basic consensus and many young parties which lead to complex coalition governments with an often unstable political majority.

Adjustment dynamics in EU-15 will mainly be shaped by globalization and the impact of US economic dynamics (and developments in Asia) plus monetary policy in the Euro zone and economic policy at the national level as well as phasing out of generous financing through EU structural funds which typically had been used to stimulate capital intensive production. (under most programs, investors received an explicit subsidy on investment in machinery and equipment.) For the main producers of machinery and equipment, this phasing out of massive structural funds financing in EU-15 will not mean a major problem since falling demand in relatively poor regions of EU-15 will be replaced by massive increases in the political and economic demand for modernizing the capital stock and capital deepening in EU accession countries. The EU-15 region will, however, notice the growing impact of fast rising exports of EU accession countries in certain commodity groups. Here some relative prices in the single market could fall strongly, and in poor EU-15 regions where labor mobility and labor market flexibility is insufficient there could be a gradual rise of unemployment. The unemployment problem in some EU-15 countries might be aggravated if a massive emigration of young people in eastern Europe should occur. It is obvious that developments in Germany, Italy and France – all already facing high unemployment – will be most critical within the Eurozone.

In section 2, attention is directed to some selected indicators for structural change in transition countries. Section 3 explores some basic analytical categories which help to develop an understanding of the dynamics of structural change in eastern European accession countries, where our interest is mainly on Poland, Hungary and the Czech Republic. Section 4 offers a closer look at the implications of structural change on EU-15, which can be expected to specialize more on products which use human capital and technology relatively intensively. Section 5 then suggests some future research steps; finally, there are two technical appendices which point out main alternatives for calculating the intensity of structural change and the degree of relative specialization, respectively. Essentially, we argue that part of the structural change observed in transition countries is well in line with what economic analysis would predict. At the same time we cast some doubt upon the familiar perception that EU-15 can be considered a rather homogenous country group.

## **2. Patterns of Restructuring the Economies in Central Europe**

Since the beginning of the 1990s, the Central European and Eastern Countries (CEECs) have undergone profound changes in their economic structures. The abolishment of central command and the establishment of hard budget constraints assigned the responsibility for production decisions to the respective enterprises. In order to be successful, actors in the market had to identify their comparative advantages and restructure or reorganize their activities. This required investing in modern machinery, changing the production technology, finding new marketing channels and many further steps. Because of the opening up of transition economies, restructuring and specialization has been observed not only from a national, but also from an international perspective. Firms in various sectors faced new or increased import competition, access to new markets, technologies and suppliers as well as the presence of foreign investors.

The CEECs countries have adjusted to changing external competitive pressure and exchange rate adjustments and had to find their respective position in the international division of labor. This process continues in the context of EU-enlargement and the establishment of a single market. Thus we turn to an overview of the restructuring of the economies of Hungary, Poland and the Czech Republic and draw comparisons to other accession countries.

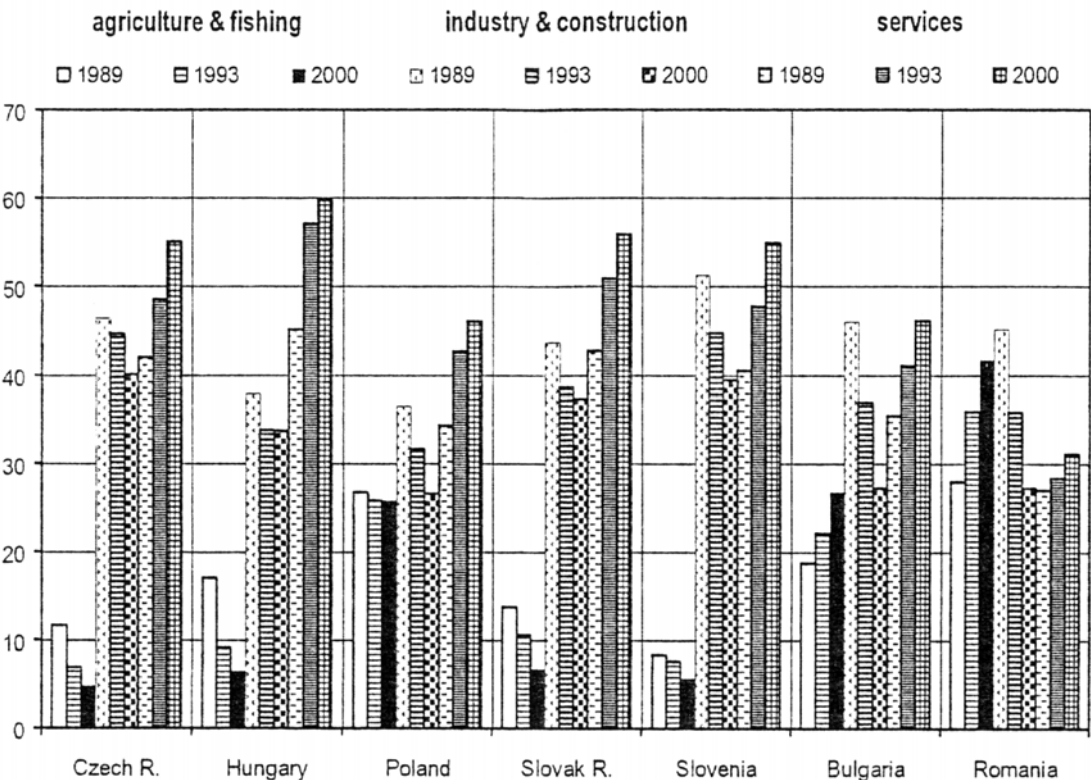
### **2.1. Changes in the Employment and Value Added Structures of Economic Sectors**

In the 1990s, the structural composition of the economy has changed dramatically in terms of employment. In general, we can observe processes of de-agrarization, de-industrialization and tertiarization (LANDESMANN, 2000). The share of employed in agricultural sectors dropped from between 10 to 15 % down to approximately 5 % in the Czech and the Slovak Republics, Hungary, and Slovenia (see figure 1). Only in the case of Poland, where agriculture already initially played a major role, has the decline been

modest: from 27 % to 25 %. In Bulgaria and Romania, the share of agriculture and fishing even rose in the course of transition. In all countries except for Romania, the absolute number of people employed in the primary sector fell (LANDESMANN/STEHNER, 2002).

The same is true for the industrial sector, albeit the loss in the number of jobs was not as sharp as in agriculture. In the period from 1993 to 2000, the share of employed in that sector fell from 45 % to 40 % in the Czech Republic, from 38 % to 34 % in Hungary and from 36 % to 28 % in Poland. In comparison with EU countries, these figures are still relatively high. In most countries presently forming the EU, the share of industry in employment is well below 30 %.

**Fig. 1: Comparison of CEEC's Employment Structures in 1989, 1993 and 2000 (based on registration data)**



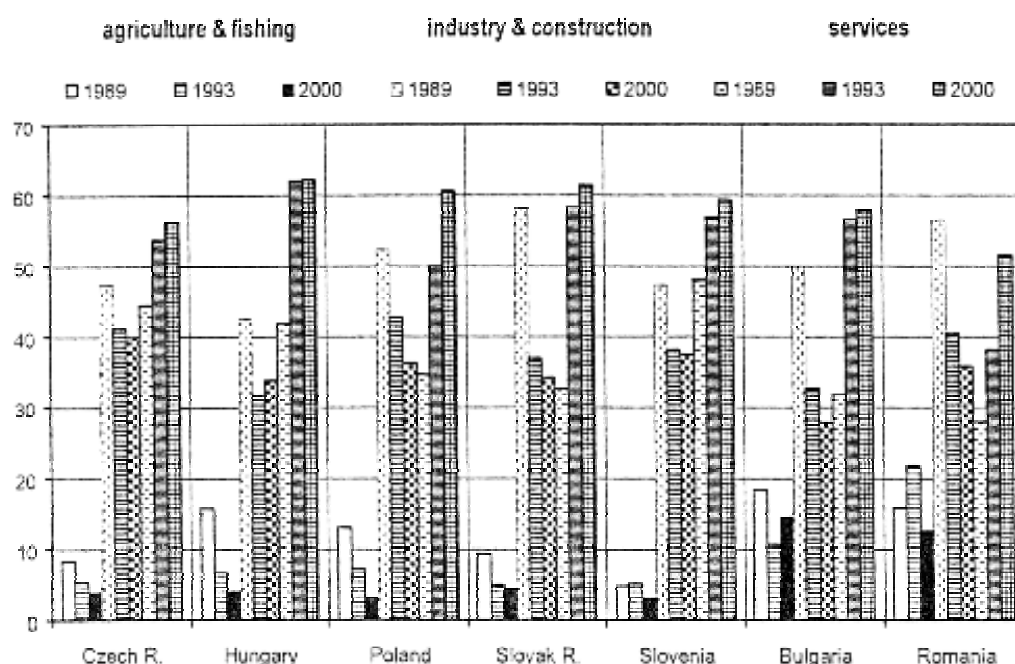
Source: WIIW (Landesmann/Stehrer, 2002, p. 4)

The importance of the service sector on the other hand rose in all accession countries. The share of people employed in the tertiary sector jumped to 60 % in 2000 from initially 44 % in Hungary and reached levels well above 50 % in the Czech Republic, Slovenia and Slovakia. In Poland, it increased from 34 % to 46% in the course of the 1990s. A high share of the services is industrial services. The shares in the transition countries have not reached the shares of employment of the EU countries, but the process of catching up in combination with structural change is obvious. In their analysis, LANDESMANN/STEHNER (2002) identify a structure of employment, that is typical for EU-countries. Of course, there are differences across the countries, but the authors find that the transition countries converge towards the average structure of the present EU. It is worth noting that apparently the growth rates do not depend on the initial levels of

employment shares. The structure of Poland's economy is different from the economies of the current European Union even more substantially than the Hungarian and the Czech economy. The employment structure in all these economies has gradually converged towards the structure in the EU; adjustment has been fastest in Hungary. In comparison, Poland showed only modest restructuring. The Polish agricultural sector is especially quite persistent. It can be questioned, if a convergence in structure can actually be expected.

The figures on the gross value added (GVA) by sectors show the same overall trend. The agricultural and the industrial sectors have shrunk while the service sector has grown (see fig. 2).

**Fig. 2: Comparison of CEEC's Value Added Structures in 1989, 1993 and 2000**



Source: WIIW (Landesmann/Stehrer, 2002, p. 5)

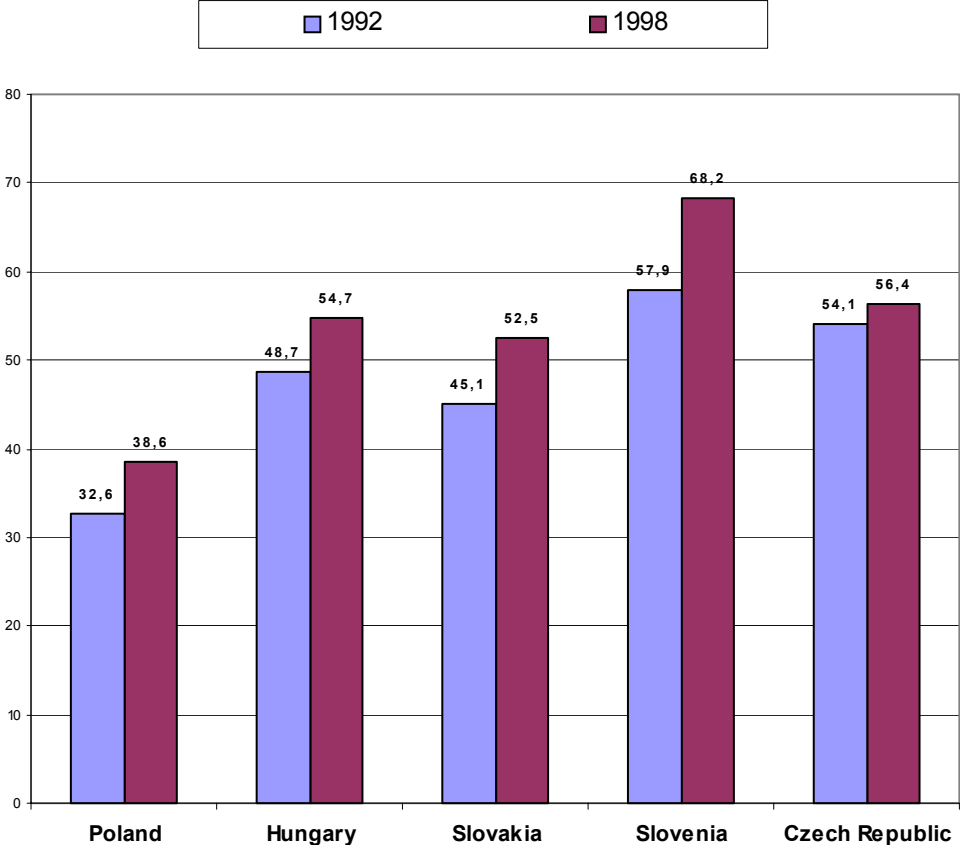
But unlike in terms of employment, the downsizing in the industry did not continue in the end of the 1990s in all countries. In Slovenia and the Czech Republic, the share of the industry in GVA stabilized. In Hungary, it even started to increase. This reveals improvements in productivity and may indicate that these CEEC's manufacturing industries are attractive locations in the context of an overall European division of labor.

## 2.2. Changes in Labor Productivity and Structure of Manufacturing

Productivity has risen in all countries, but changes differ significantly across countries. In the period between 1993 and 1999, overall labor productivity in the Czech Republic rose by 19.5 % (STEPHAN, 2000). This growth rate is quite modest in comparison with the other transition countries: Poland and Hungary have experienced improvements of 28.9 %, Slovakia, Slovenia and Estonia even more than 30 %. All of these countries are on the way to closing their productivity gap vis-à-vis the EU, since the productivity in the EU-15 rose by only 14.7 % in the same period. But the overall absolute gap is still very high. The level in Hungary and the Czech Republic was just above 50 % in 1998 and Poland was even

below 40% of the EU-15-level (see fig. 3). But in the case of Poland, the high share of the relatively low-productivity agricultural sector contributes to the low performance in terms of productivity. If Poland’s employment structure was in alignment with the economies currently in the EU, productivity would be above 50 % as well (STEPHAN, 2000). We can expect benefits for all transition countries if the composition of their economies converges towards the composition that is typical for EU-countries.

**Fig. 3: Labor Productivity Gaps in Central Europe in 1992 and 1998 (EU-15 = 100)**



Source: IWH (Stephan, 2000, p. 378)

In all transition countries, unit labor costs are much lower than in the EU (PODKAMINER ET AL., 2003). Wages differ across and within the sectors, but the differentiation is not as high as in productivity (LANDESMANN, 2000). Thus, the sectors and branches that managed to improve their productivity the most have the best position in international competition.

The EUROPEAN COMMISSION (2003, pp. 220-230) has summarized some of the major changes in labor productivity and costs in accession countries – the benchmark being Austria. In the late 1990s for the manufacturing sector as a whole, the productivity gap narrowed for the Czech Republic, Hungary, and Poland while it widened in the other transition countries. There were considerable differences across industries. Particularly, all accession countries except Slovenia and Bulgaria narrowed the relative gap in the high-

tech industries. The position of the latter two countries fell back relative to Austria in all sectors (low-tech, resource-intensive, medium-high-tech), however, the gap increased more in the low-tech and resource-intensive industries than in the medium-high-tech industries. Interestingly, cross sectoral gaps in wages were much smaller than those for productivity. There were large differences in dynamics across industries and countries: Hungary was quite successful in reducing relative unit labor costs in the medium-high-tech sectors from 66 % of the Austrian level to about 22 % in 1999.

If one compares the percentage deviation in export shares of the accession countries of those of the EU-countries without the cohesion countries Greece, Spain and Portugal (EU-north) and compares them with the deviation of the latter three countries we get several important observations (EUROPEAN COMMISSION, 2003, p. 223):

- “In general, in 1995 there was a strong representation of labour-intensive industries in the export structure of the ACs as compared to the export structure of the ‘EU-north’. For Bulgaria, Poland, Romania and the Baltic countries this dependence on labor-intensive industries was much stronger than for the ‘EU-south’. Over the period 1995 to 2000, this dependence further increased for Bulgaria, Latvia, Lithuania and Romania while for the other countries it declined relative to the ‘EU-north’ – for some ACs quite sharply.”
- “With respect to technology-intensive industries, the ACs started off with sizable ‘deficits’. Over the period 1995-2000, these deficits declined substantially in the Czech Republic, Estonia, Hungary and Slovakia and (in Estonia and Hungary they even turned into ‘surpluses’), while the decline was more moderate in Poland. In Bulgaria, Latvia, Lithuania and Romania these deficits remained at very high levels and in some cases increased further.”

For some transition countries, the specialization in labor-intensive industries reduced, at the same time the role of technology-intensive industries increased. It seems that other countries got locked in in labor-intensive sectors. As regards export unit values the gaps of accession countries relative to EU-15 decreased considerably – in particular in technology-intensive industries.

### **3. Analytical Perspectives on Structural Change in Eastern Europe**

Empirical analyses by KUZNETS (1957), CHENERY (1960) and others (eg CHENERY/ROBINSON/SYRQUIN, 1986) derives sectoral structural patterns which mainly are explained by per capita income. CHENERY (1960) argues that sectoral patterns in different countries would be similar if countries were identical with respect to universal influencing factors: technological knowledge, preferences, access to the same set of export markets and import markets, accumulation of real capital and human capital as a function of per capita income. If countries would be indeed subject to these common set of universal influences, a cross country analysis of countries - with different per capita incomes - at a given point of time would show the same results as a times series analysis for one country (evaluating economic structure at various income levels and points of time, respectively). The empirical data analysed by CHENERY (1960) showed that sectoral

output elasticities were relatively high with respect to per capita income in industry and relatively low in agriculture.

Based on the empirical set of income elasticities, it is thus possible to make projections for future output shares of sectors/industries. Moreover, as the agricultural sector shrinks along with rising per capita income, there will be labor reallocation towards the industrial sector. With respect to eastern Europe, such a development did indeed take place in the late 1990s, once the early transformation recession coupled with industrial restructuring was over. Hungary, the Czech Republic as well as other transition countries face such a transitional recession going along with declining industrial output (HAVRYLYSHYN *ET AL.*, 1999). Such a decline in industrial output also seems to be a natural adjustment process to the extent that socialist countries had been characterized by particular inefficiencies in the investment goods sector – due to the interaction of a political bias in favour of growth and the systemic problem of a soft budget constraint – which led to oversized sectors with respect to producing machinery and equipment (WELFENS, 1992). Finally, economic opening up which was rather gradual in most transition countries, except for Poland, will also affect the relative production of machinery and equipment. As inflows of foreign direct investment bring a greater role of western multinational companies – plus MNCs from Japan, Korea and Taiwan –, there will be a certain bias with respect to the growth of imports of machinery and equipment. MNCs often prefer to rely on the same major suppliers of machinery and equipment which they have in their headquarter country and some other key production locations.

As regards structural change, the impulses come both at the microeconomic level and the macroeconomic level. As regards the latter, both supply-side effects and demand side effects will be important. Demand side effects are associated with the role of income elasticities (Engel curves) while technological dynamics at the sectoral and multi-sector level – possibly in combination with spillover effects – are key elements on the supply-side. Backward linkages and forward linkages in major industries also could be of particular relevance; in this context, dynamic changes in the context of changing products and prices in the intermediate goods sector might also play a role. SCHUMPETER (1934; 1939) has presented a view which emphasizes the role of entrepreneurship and innovativeness where the latter can mean both product innovations and process innovations. Product innovations crowd out established traditional products, and diffusion over time reinforces the role of such innovations over time. Macroeconomic impulses such as long term changes in the real interest rate or real unit labor costs could also influence the dynamics of structural change (e.g.. a fall of the real interest rate will stimulate expansion of capital intensive sectors).

As regards eastern European transition countries, one may well anticipate a long-term fall of the real interest rate and the cost of capital, respectively, once these countries are full members of the EU and later of the Euro zone. Full membership will reduce the risk premium in capital markets and also reinforce financial market integration so that nominal interest rates should fall (relative to the inflation rate). Anticipation effects of membership in the Euro zone could reinforce this process. To the extent that capital intensive industries expand in the medium term within eastern Europe, one must raise the question whether the demand for skilled labor will grow relatively or not.

In a Schumpeterian view one may point out that economic recessions and stagnations are characterized by bankruptcies while periods of economic expansion are associated with the creation of new firms. As EU membership is expected to reinforce economic expansion



in the medium term, one may indeed anticipate a higher birth rate of new firms in accession countries.

An important question is in which sectors new firms indeed will be created. Naturally, there will be special opportunities for expansion of domestic entrepreneurship in sectors with increasing outsourcing. Since almost all socialist countries were characterized by a high degree of vertical sectoral integration, it is obvious that sectors which were quickly privatised – normally those which had small problems in terms of competitiveness – allowed special opportunities for the creation of new firms. This does not rule out that in the course of a market-driven long term evolutionary process, new patterns of sectoral vertical integration would develop. Another aspect concerns the scope and role of domestic capital markets. While real capital costs might decline in the context of EU accession, one cannot expect banks to easily finance capital-intensive production. Owners of firms might have insufficient capital of their own to convince banks to finance such production. Even if one might argue that in capital-intensive sectors it should be easy to come up with adequate collateral for bank loans, one must not overlook that profitability of intermediate input producers in accession countries might be rather volatile due to the fact that foreign investors and the firms which buy the intermediate products, respectively, might switch production to other countries in the course of time. The rise of IBM's hard disk production in Hungary in the late 1990s followed by its closing down a few years later provides one such example. Catching-up quickly – and hence facing strong wage pressure – might thus generate some problems.

The more underdeveloped the financial sector, the more difficult for young firms to finance capital intensive production. If as a consequence firms specialize in relatively labor intensive production, this might ultimately not reflect too much relative abundance of labor but rather the inability to develop competitive banks and efficient stock markets. This aspect has hardly been discussed in the literature and might well deserve further investigation.

An interesting question is whether there can be balanced growth in combination with structural change. In the models of ECHEVARRIA (1997) and KONGSAMUT/REBELO/XIE (2001), structural change is caused by a non-homothetic demand function. As a result there can be structural change and growth at the same time – however, structural change will slow-down over time. MECKL (1999) has presented a model driven by R&D, in which balance growth and structural change will occur at the same time so that some basic implications of standard neoclassical growth models do not automatically become invalid in the context of structural change. LAITNER (2001) has developed a model which shows how expansion of the industrial sector and structural change, respectively, lead to an endogenous increase in the savings rate, in turn stimulating capital deepening. From this perspective, one may further conclude that such a mechanism will then improve the opportunities of sectors producing investment goods and related intermediate products.

### **3.1. Analytical Categories**

The relative per capita income position of poor new member countries will increase over time. Indeed one may anticipate that these countries will catch up with the average EU per capita income in the long run. Such a catching-up process naturally will go along with structural change, and which type of structural change one should expect is a key issue to be answered on the basis of economic analysis. Whether such a catching-up process will go along with a fall or rise or stable EU-15 growth rate is another topic.

Catching up in accession countries is likely to be stimulated by several different forces:

- endogenous domestic market dynamics – partly shaped by market entry and consolidation within industries – which will bring about a change in the structure of output and a rise of per capita incomes along with a rise in productivity growth
- policy-induced changes which will involve infrastructure modernization, modernization of the education sector – human capital formation – and a gradual rise of R&D promotion relative to GDP. A certain level both of human capital and of “R&D capital” (this can be calculated in a perpetual inventory method, that is from cumulated R&D expenditures minus depreciation) is necessary for efficient learning processes in the sense of adopting knowledge and technologies of leading industrialized countries. A rapid modernization of the education sector is partly dependent on the budget situation; high budget deficits would force governments to trim many budget lines, possibly including education expenditures
- single market dynamics in the sense of rising trade and foreign investment flows, where the first decade of accession certainly will focus mainly on inward FDI from EU-15, the US and some other OECD countries. Accession countries are low wage countries which additionally offer relatively cheap electricity and land so that full EU membership should stimulate FDI in key areas of the economy. Given the low level of per capita GDP (evaluated at PPP rates) and the low R&D expenditures relative to GDP in post-socialist countries in 2003, we can largely rule out that FDI inflows will be in high technology sectors. Rather, we can expect high FDI inflows in labor intensive sectors on the one hand, and in medium-technology industries in leading transition countries such as Hungary, Poland, the Czech Republic or the Slovak Republic on the other. In some cases, one also may find FDI in natural resources.

From a theoretical perspective it is useful to distinguish between Schumpeterian goods and Non-Schumpeterian technology-intensive goods; as regards the latter, production and R&D can be organized in different places/countries, respectively, so that high – and possibly growing – differences in international labor costs will stimulate outward FDI flows from high wage countries in Western European countries. Schumpeterian technology intensive goods, where R&D and production cannot be located in two different locations as the R&D process is strongly linked with the production process – e.g. as in the case of airplane production –, labor cost advantages of EU accession countries will not trigger major relocation of EU-15 firms. To some extent, EU accession countries could benefit from product cycle trade so that in non-Schumpeterian technology-intensive sectors MNCs from EU-15, the US etc. will locate production of goods in the standardization stage in low wage economies of eastern Europe.

A key point with respect to long-term adjustment concerns the importance of trade as a determinant of economic growth. From basic textbook models and empirical analysis, one expects that economic opening-up and growing trade can contribute to output growth. The expansion of the tradables sector is crucial because productivity growth in this sector is typically higher than in the nontradables sector such that the relative price of tradables in terms of nontradables will fall with economic development and per capita income (Balassa-Samuelson hypothesis). With respect to the link between trade and growth, a strong impulse for long term economic catching-up comes from rising exports of manufacturing goods, as is argued in the literature. It is clear that eastern European accession countries will be eager to broaden the share of manufacturers in exports as a

basis for economic catching up. EU-15 import markets are large and their volume is growing over time, making them attractive targets for firms from eastern Europe.

For the Visegrad countries, economic catching up and sustained growth are natural policy priorities at the beginning of the 21st century. The achievement of economic catching up can be approached from several analytical viewpoints – one could draw on historical case studies, on economic theory or on simulation studies. The alternative is simply to muddle through, an option which is predestined to failure in the long run.

Facing high unemployment rates of close to 10% and low wages in eastern Europe, there should be room for the expansion of labor intensive production. Given the relatively large endowment of human capital, there could also be some long-term scope for rising output and exports in knowledge-intensive sectors. Indeed, the EBRD's (1999) export analysis of selected transition countries has shown that Hungary already increased the share of technology-intensive exports in the late 1990s. It is, however, an open question whether the innovation systems in all Visegrad countries can be modernized quickly so as to make many or all Visegrad countries attractive for foreign investors in technology intensive sectors.

Concerning theory, the new growth theory and the new international trade theory offer interesting ingredients for a potential catching-up strategy. Knowledge accumulation and national plus international productivity spillover effects are emphasized in these new approaches. This does not suggest that one should overlook the traditional benefits of trade, which come both on the import and the export side (plus the option of recording temporary current account deficits).

### **3.2. Specialization, Innovation and Growth: Perspectives for Transformation Countries**

Transforming (Visegrad) countries were traditionally specialized in medium technologies and low technology goods where many research activities were organized along branch lines in the socialist command economy. This sectoral R&D focus has changed with the transformation to a market economy; in most western OECD countries, process innovations come from outside the innovating sector. Hence a more flexible and dynamic innovation process will be needed in postsocialist countries. In the early transition, there was a transformational recession in eastern Europe in which firms facing underdeveloped capital markets and a decline in domestic demand typically were cutting R&D expenditures. With the start of the transformation process in the early nineties the R&D intensities in the Central and Eastern European countries were reduced dramatically (BMBF, 1999). The actual average R&D intensities of most transition countries from 1987 to 1997 (or the most recent year available) are displayed in figure 4. Nearly all of these countries show R&D intensities below 1%, which is in the range of the R&D intensities of low to medium income countries. The only countries which show slightly higher R&D intensities are the Czech Republic, Slovak Republic and Slovenia.

This poor position of the transition countries is also obvious when the comparative disadvantages in R&D personnel are considered (figure 5). The measure used here is the relative technological capability share (*RTS*) calculated as:

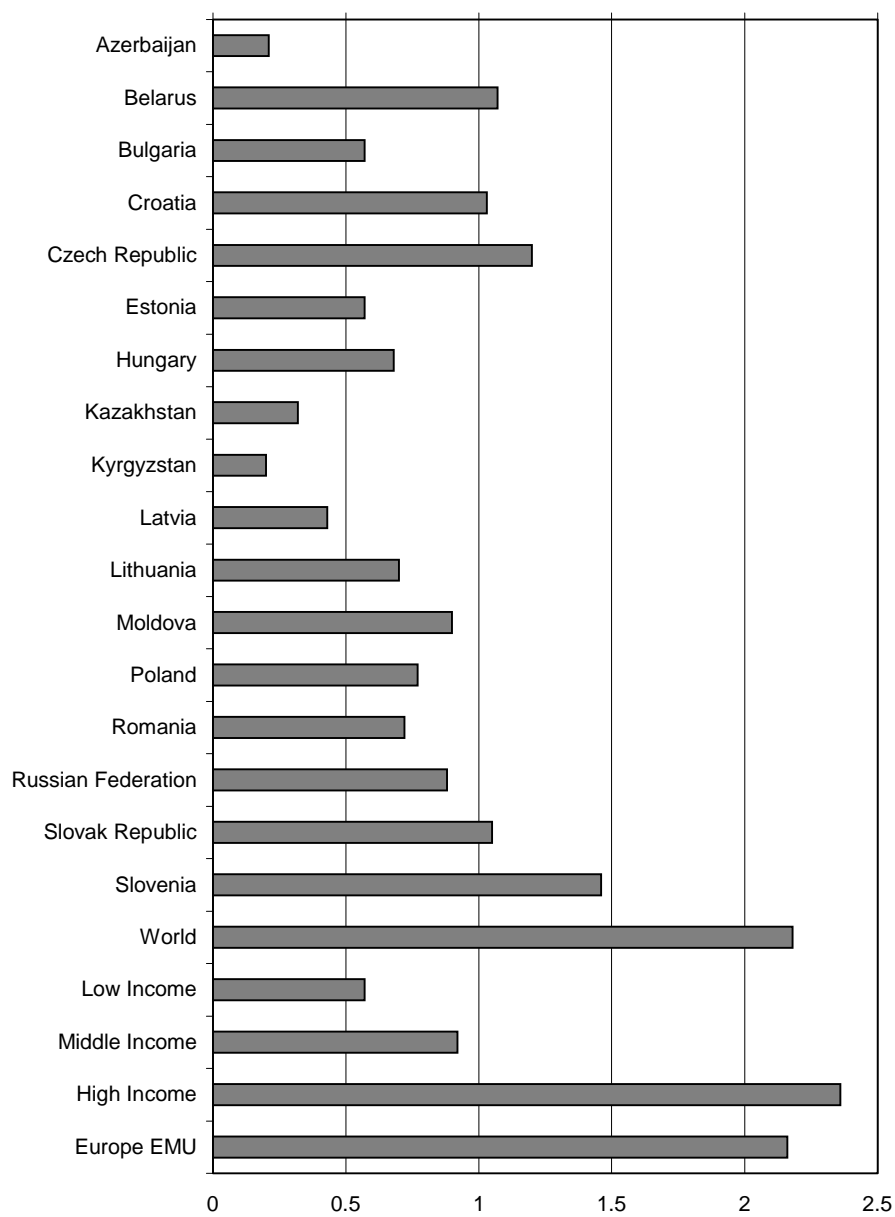
$$(1) \quad RTS = 100 \cdot \log \left( \frac{\text{Scientists and engineers in R \& D in country } i}{\text{Scientists and engineers in R \& D worldwide}} \right) \text{ respectively}$$

$$(2) \quad RTS = 100 \cdot \log \left( \frac{\text{Technicians in R \& D in country } i}{\text{Technicians in R \& D worldwide}} \right).$$

Nearly all transition countries show strong relative disadvantages, i.e. negative *RTS* values for scientists and engineers as well as technicians in R&D. Concerning scientists and engineers, only Azerbaijan and the Russian Federation show slight positive values. The situation is of particular concern as disadvantages in the sector of technicians – a profoundly important element in imitation and incremental innovation – are extraordinarily large. If it holds true that native national technological capabilities are an essential ingredient for technological imitation and catching-up, national policy must aim at improving their absolute as well as relative technological capabilities. It is well-known from South East Asian NICs that these countries invested a lot in their capabilities to imitate before they became innovators on a world market level (JUNGMITTAG *ET AL.*, 1998).

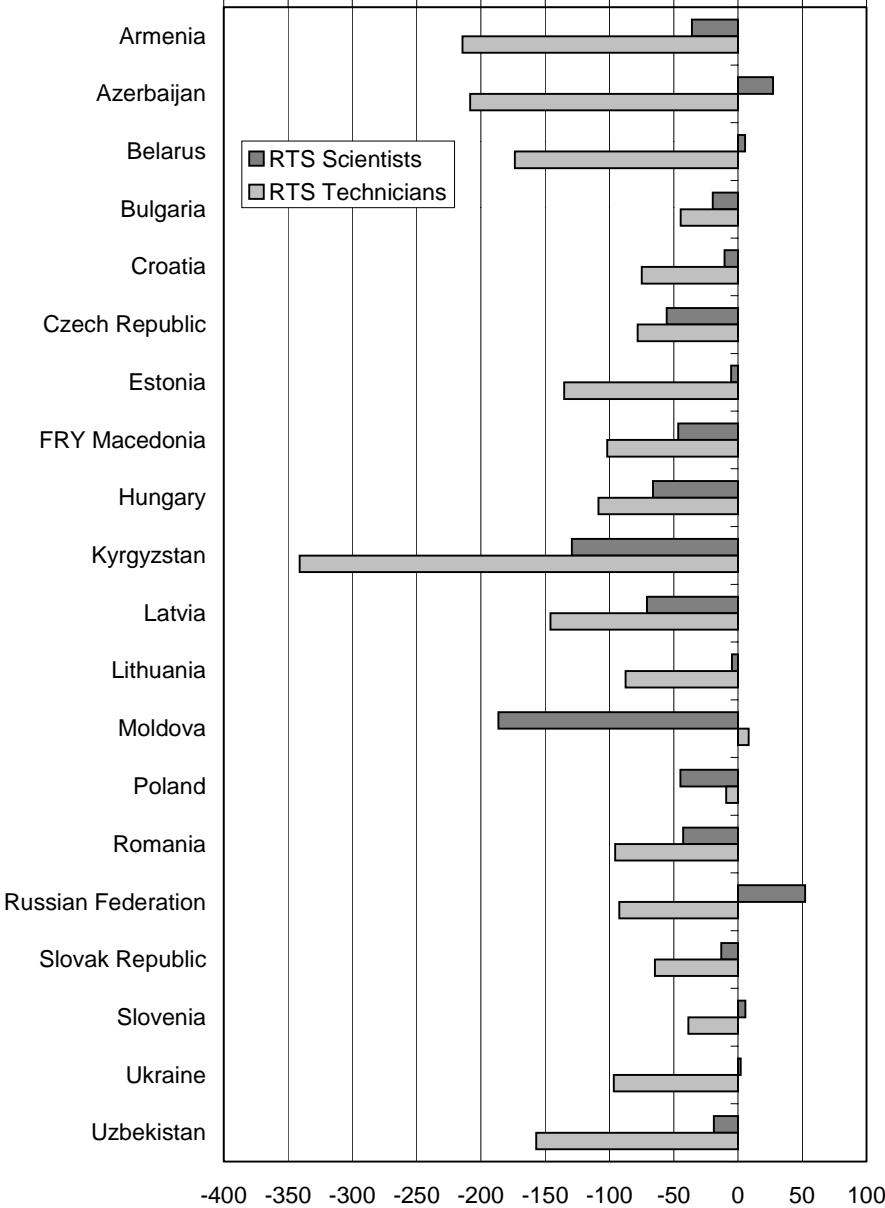
R&D is normally associated with the input side of the science and technology process (or innovation process if innovation is on the agenda of the development process), whereas patents are an indicator of the output of this process when a country moves from merely imitation to innovation. Figure 6 shows that most if not all transition countries have not reached this threshold in terms of international marketable innovations. It displays the patent applications per one million inhabitants at the US Patent and Trademark Office. With the exception of Slovenia, Hungary and perhaps the Czech Republic, these numbers are infinitely small. This again points out that the role of nearly all transition countries is imitation and not innovation.

**Fig. 4: Average R&D Intensity of Transition Countries 1987–1997 (or latest year available)**



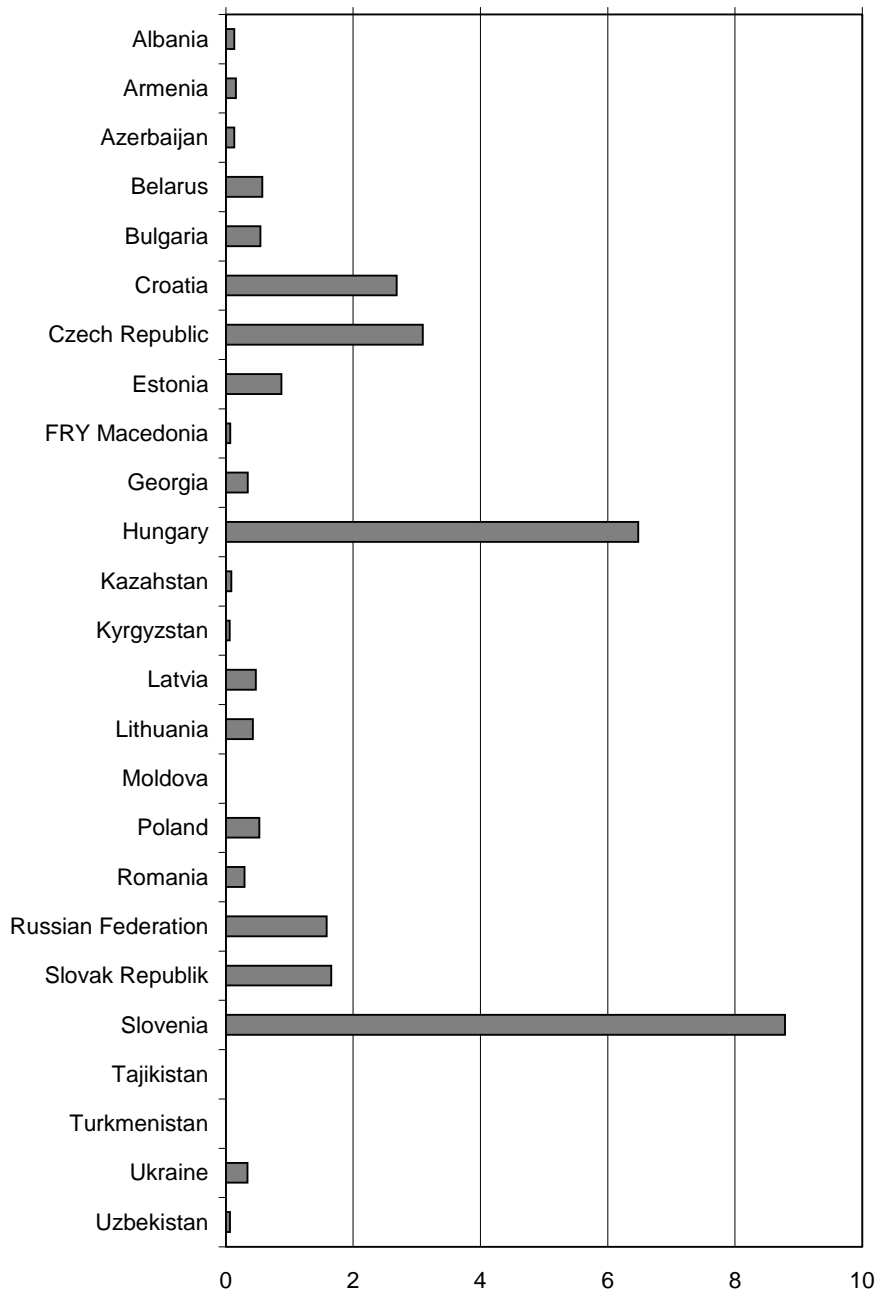
Source: WORLD BANK (2000), Table 5.12, p. 306–308.

**Fig. 5: Comparative Disadvantages in R&D Personnel of Transition Countries 1987–1997 (or latest year available)**



Source: World Bank (2000), Table 5.12, p. 306–308; own calculations.

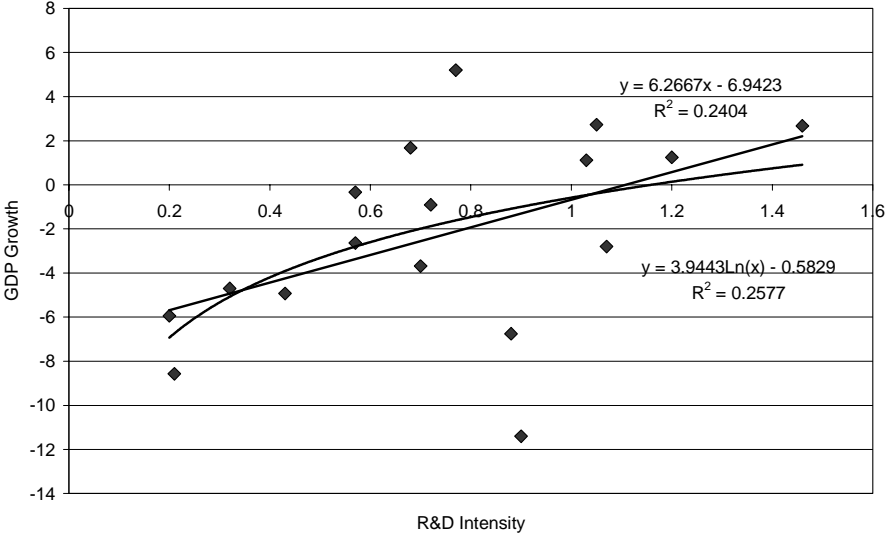
**Fig. 6: Patent Applications at the USPTO (per one Million Inhabitants) 1992–1998 of the Transition Countries**



Source: USPTO (2000); EBRD (1999); own calculations.

There is a significant link between R&D and growth performance in transition countries. For answering this question JUNGMITTAG/WELFENS (2003) considered the correlations between these two measures. Looking at the relationship between R&D intensity between 1987 and 1997 and growth of GDP from 1992 to 1998, the linear specification as well as the specification with R&D intensity in logs were statistically significant at least the 5 % level (see figure 7).

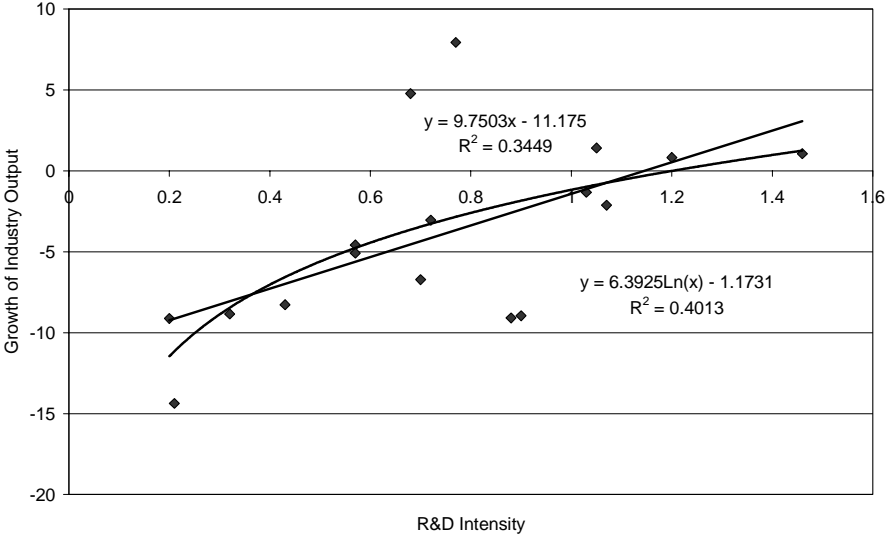
**Fig. 7: R&D Intensity and Growth of GDP in Transition Countries**



Source: EBRD (1999); World Bank (2000); own calculations.

The link between R&D and growth becomes even more obvious when growth of industrial production from 1992 to 1998 is considered. Now both correlations – the linear specification as well as the specification with R&D intensity in logs – are statistically significant at the 1 % level (figure 8). The better fitting of the specification with R&D intensity in logs points to the fact that R&D intensity tends towards a certain limit or shows at least – like other inputs – diminishing marginal returns.

**Fig. 8: R&D Intensity and Growth of Industrial Production in Transition Countries**



Source: EBRD (1999); World Bank (2000); own calculations.



All this points to the fact that qualitative factors affecting innovation systems should be taken into account as well as quantitative indicators (FREEMAN/SOETE, 1997). This interplay between the institutional framework (the qualitative part) and purely R&D measures can best be highlighted by a comparison of the national innovation systems. In the socialist countries, there had largely been a failure to develop efficient R&D at the enterprise level.

### 3.3. Technology Gap Approach

From the theoretical viewpoint of a “technological gap” approach, we have to differentiate between three possible scenarios with respect to technological catching-up (STEHNER/WÖRZ, 2001). In his seminal work, GERSCHENKRON (1962) developed the idea of an “advantage of backwardness” which results from the fact that backward countries can choose for their imitation processes between different technological trajectories and opportunities. As regards the choice of technologies, he concludes that for catching-up countries backward countries put emphasis on expanding those sectors in which – from an international perspective – recent rates of technological progress had been relatively strong. Thus, a backward country can combine the effect of capital deepening with labor-saving technologies so that there are additional opportunities for productivity growth as workers laid off in low-productivity sectors can move to sectors which produce more sophisticated products and represent high productivity. The implication is that there are very different trajectories for catching-up where the combination of capital deepening and focusing on sectors with high Schumpeterian dynamics could generate relatively strong growth. Such a developmental approach can be dubbed the leapfrogging strategy.

However, an opposite scenario is also imaginable in which technological catching-up will first take place in low-tech industries, and only when the initial gap has reached a certain threshold will the backward country start to close its gap in the next more technology-intensive industries. This kind of asymmetric technological diffusion is considered in a variant of a formal model in GRIES/JUNGBLUT (1997) and the respective scenario can be labelled as “climbing-up-the-ladder strategy”. In a third approach, it is assumed that backward countries improve their technology at such a rate that their gaps are reduced in all industries at the same speed. This kind of symmetric technological diffusion is considered in the first variant of the previously noted model of GRIES/JUNGBLUT (1997) and within the context of international trade in a model in KRUGMAN (1985). This can be labeled as the “continuous convergence scenario”.

Based on these theoretical scenarios, STEHNER/WÖRZ (2001) investigated the catching-up process of OECD-North countries, OECD-South countries (Greece, Iceland, Portugal and Spain) and East Asian countries (Hong Kong, Indonesia, Korea, Malaysia, Singapore and Thailand) relative to the USA. Their results, which due to data problems (e.g. the data are expressed at current prices and current PPP) have to be considered somewhat cautiously, show that productivities in the OECD-North and South countries converge towards the US level in low-tech and medium-low-tech industries but not in medium-high-tech and high-tech industries, while East Asian countries’ productivities converge towards the US level in low-, medium-low- and medium-high- industries but not in high-tech industries. Considering also the behavior of wages and unit labor costs, the authors conclude that East Asian countries realized a competitive advantage in the medium-high-tech industries and that their catching-up behavior better fits the first scenario (“jumping-up”) whereas the catching-up behavior of the OECD-South countries

fits more in line with the second scenario (“climbing-the-ladder”). However, they also mentioned “... that catching-up patterns ... do not always follow the patterns implicitly assumed or proposed by the models...”

Finally, we focus on some ideas about the link between export growth, productivity gains and economic growth (cf. also WELFENS, 1999 and WELFENS/GAVRILENKOV, 2001). Economic opening-up will normally stimulate economic specialization in line with comparative economic advantage which raises economic welfare, as consumption can be increased. This standard textbook argument, however, does not explain why rising exports of manufacturing products go along with relatively strong productivity gains. JUNGMITTAG/WELFENS (2003) have emphasized several points, including the fact that firms which learn to organize production for world markets adopt a dynamic benchmark that can stimulate successful catching-up along the technology ladder. Moreover, as firms move from low-technology towards medium technology products, there are rising opportunities for product differentiation and hence for price discrimination which help to raise export unit values and profits rates, respectively. It is also noteworthy that successful exporters often quickly become intelligent importers which buy critical intermediate products in competitive world markets. Moreover, there could be geographical network effects and regional integration effects that are associated with the logic of the gravity equation, emphasizing that economic geography matters; simultaneous liberalization of trade in neighboring countries can be expected to bring higher growth effects than had through isolated liberalization. Finally, we add a well-known aspect but modify it in an important way. The (manufacturing) tradables sector is quite competitive, meaning that inefficient specialization will result in high losses and bankruptcy. The pressure of world market competition thus helps by avoiding the trap of inefficient specialization with no or poor productivity gains. This in turn could stimulate FDI inflows because foreign investors will anticipate that a high degree of manufacturing openness will reduce the risk of inconsistent government intervention. With respect to structural change, government intervention naturally plays some role in EU accession countries, in particular since they will have access to EU structural funds. At the same time, governments in EU-15 countries might want to influence the process of structural change in the context of EU eastern enlargement.

#### **4. Adjustment in EU-15 Countries**

While East European accession countries can be expected to catch up in terms of technology and per capita income – the latter giving rise to an increase in the share of intra-industrial trade in the enlarged EU –, countries in the EU-15 group can be expected to specialize more on R&D-intensive products and goods which use human capital intensively. This would largely be in line with the logic of the HOS approach. Moreover, a basic traditional assumption is that eastern enlargement basically affects the EU-15 in three ways, as was emphasized e.g. in the study by GRASSINI (2002) for Italy:

- Rising import competition in low technology fields and some medium technology fields, thereby partly reflecting modernization of the capital stock as well as capital accumulation plus technological catching-up in Eastern Europe, which can be characterized as a low wage region.

- Rising exports of EU-15 which reflect the increase of per capita income in Eastern Europe and thus rising import demand.
- Rising EU-15 imports in the field of low technology goods and some medium technology products – in particular labor intensive products and relatively cheap consumption products (some of them with scale economies), respectively. Import competition will reduce the price level in EU-15 countries; or reduce inflation rates to figures that are lower than without EU eastern enlargement. This has positive real income effects and will stimulate aggregate consumption, along with the relative price effect for standardized consumption goods.

It is, however, doubtful to treat EU-15 as a homogenous group of countries as is often done in the literature. Indeed, the EU 15 countries are not a homogenous group and as such we must adopt a more careful analytical perspective:

- The logic of the gravity equation suggests that countries close to accession countries will particularly benefit from export expansion associated with catching-up in eastern Europe. Sweden, Finland, Denmark, Germany, Austria and Italy plus Benelux and France will thus benefit more.
- There are crucial differences across EU-15 countries when it comes to the absolute and relative size of investment goods producing sectors which are poised to benefit from growing overall (including intra-EU) exports in the context of EU enlargement. Germany, France, the Netherlands, Austria and – to a lesser extent - Italy are major producers and exporters in this field.
- There also are crucial differences across EU-15 countries in terms of the role as source country of foreign direct investment. Germany, France and the Netherlands plus Austria are the four leading economies in this respect. (The relatively small share of industry in British GDP and its traditional low profile in eastern Europe give British FDI only a minor role in EU accession countries.) This is important because vertical FDI outflows from EU-15 will create new opportunities to export intermediate inputs to eastern Europe on the one hand; on the other hand, a higher outward FDI stock will imply a long term rise in profits accruing abroad and hence a stronger rise of GNP as compared to GDP. Finally, a strong FDI presence in eastern Europe's low wage economies will facilitate firms in obtaining wage moderation at home. This aspect of FDI in eastern Europe so far has rarely been analyzed in the literature. Relative to the size of the economy, FDI outflows to eastern Europe are highest in Austria which thus can be expected to experience strong wage moderation and hence an improvement of international price competitiveness. These aspects deserve closer inspection. One may also note that gradually rising import competition from eastern Europe plus East European technological upgrading will stimulate firms in EU-15 to specialize more on products which use human capital and technology intensively. However, one must also raise the policy issue of whether governments in EU-15 – often facing very tight budget constraints – will raise expenditures (relative to GDP) in the field of education and innovation adequately. Sweden, as the European OECD leader in the field of spending on these two growth-enhancing items, has spent almost 4% of GDP on R&D and 1.7% on higher education at the beginning of the 21<sup>st</sup> century. Germany, by contrast, reduced the R&D-GDP ratio from 2.9% in 1989 to 2.4% in 2002 and is only spending roughly 1% of GDP on higher education.

- Euro zone countries clearly differ in terms of the real interest rate. Indeed, much has changed since the start of the Euro zone as Germany no longer has the lowest real interest rate (nominal interest rate minus national inflation rate) and hence the lowest capital costs as was the case in DM times. The inflation rate within the Euro zone can be expected to be relatively low in those countries which suffer from slow growth and high unemployment on the one hand and strong import competition from eastern Europe on the other. It will be relatively high in countries with high output growth (and low unemployment rate) or weak import competition from eastern Europe. While Germany is a prime example for a low inflation economy in this regard, Spain and Ireland are examples for the second case. Thus, EU eastern enlargement will reinforce the problem that the ECB interest rate is too high for Germany and too low for Spain and Ireland. As intra-Euro zone inflation differences are mainly due to differentials in nontradables prices the main long term impact of a uniform Euro interest rates in the context of very low average inflation rates in the Euro zone is that there will be a relative expansion of investment in the nontradables sector (part of services, construction industry) which in fast growing catching-up economies might even face negative sectoral real interest rates. Germany's economy in turn will face a relative high real interest rate which will slow down German growth and ultimately growth in the whole enlarged community. Wage restraint in Germany's manufacturing industry could help improve long term competitiveness. As a matter of fact, there was no adequate wage restraint in manufacturing industry despite the fact that unit labor costs at the aggregate level of the economy reduced by 1% in the period between 1995 and 2000. Closer inspection of disaggregate data reveals that the information & technology sector alone – representing 1/10 of GDP – recorded a decline of 29% in unit labor costs. The outlier of the New Economy sectors thus creates the biased impression that collective bargaining in the late 1990s was characterized by general wage moderation. This is not true.

The first two points suggest that Germany and Austria can therefore expect particular benefits from EU eastern enlargement. The last point, however, sets a clearly negative tone for Germany, which suffers from high unemployment and an inflation rate which in the tradables sector is close to deflation. This is a dangerous situation which requires not only more wage moderation and wage dispersion in Germany but also a more loose monetary policy.

The overall Community will not benefit much from EU eastern enlargement if the main result of this enlargement is stagnation or slow growth in Germany. Facing 5 million unemployed in 2003, there is a considerable potential for political radicalization. The main losers from a slow-down of Germany's growth rates will be France and the Benelux countries, for which Germany is a very important trading partner; in addition, Poland will also be strongly negatively affected.

## 5. Future Research

An interesting statistical challenge in the context of EU structural change will be to analyze the speed and scope of structural adjustment in selected EU-15 countries and in EU accession countries; a broad range of indicators is available which are summarized in the appendix. It will be crucial to analyze why countries differ in terms of structural adjustment speed and how strong structural change contributes to productivity growth at the macro level and hence to improving international competitiveness of the enlarged EU.

As regards accession countries, it will be quite interesting to see whether there is strong evidence for Gerschenkron type catching-up effects in all new EU member countries. Indeed, one cannot rule that EU enlargement will bring differential growth rates to transition countries so that there could be gradual economic divergence within eastern Europe along with convergence in an East-West perspective in the enlarged EU. It will be interesting to highlight the type and scope of structural change over time and across countries while also taking a closer look at the degree of specialization in foreign trade. As often discussed in the literature there can be lock-in effects of early (unfavorable) specialization which could slow down economic growth. In a more favorable perspective market-driven specialization – changing over time, namely along with changes in relative factor endowments, relative prices and relative per capita income positions – will enable accession countries to benefit from productivity growth as input factors are shifted from low productivity to high productivity sectors. Depending on the interaction of slowly changing variables - such a per capita income, the price level and technology – and fast changing variables – eg interest rates, stock market prices or exchange rates – countries could develop in different ways, in particular if there are asymmetric shocks and divergent policies in the field of promotion of R&D and foreign direct investment or in the fields of collective bargaining or exchange rate policy and monetary policy. There will be, due to rising trade between accession countries and EU-15 one crucial harmonizing factor over time, namely a gradually rising dependency of accession countries on the business cycle of EU-15.

With respect to EU-15 countries, it will be interesting to analyze the different patterns of structural change and the speed of adjustment. STAMER (1999) has claimed that structural adjustment in Germany was not much weaker than that in the US in the early 1990s and 1980s. While this might be true, it is fairly obvious that Germany's labor market is much less flexible than that in the US, and as a result, German society will face much higher expenditures in terms of active labor market policies, costing about Euro 20 bill. p.a. more in unemployment compensation than the US in the beginning of the 21st Century. Moreover, the share of long-term unemployment in Germany is thus much higher than in the US. Taking a look at the broader picture and the enlarged EU, respectively, it might also be interesting to take a look at the greying of society as a potential factor slowing down the degree of structural change and hence (productivity) growth.

Naturally, the southern EU countries could face major problems in the context of EU eastern enlargement as the new member countries also are relatively poor – compared to EU-15 average – and are characterized by a low factor price ratio (wage-interest rate) and hence certain sectors with low capital intensity and high unskilled labor intensity, respectively. Such sectors will be exposed to strong adjustment pressure; not least if EU structural funds for the respective regions in the southern EU should be phased out quickly (EMERSON/GROS, 1998). Thus countries like Portugal, Spain and Greece could face particular adjustment problems which will be the more pronounced the more rigid wages

for unskilled labor is. Labor intensive sectors in southern EU countries thus might suffer from rising import competition, from losing market shares in EU-12 and from falling FDI inflows. However, from the logic of the gravity equation, there is only a weak overlap between southern Europe and eastern Europe, except for Greece. Only for south European sectors producing goods for which transport costs are rather small will eastern EU enlargement create immediate problems. Greece, however, could become strongly exposed to rising import competition, at the same time, Greece has the advantage of geographical proximity so that Greek (and foreign) investors seeking vertical integration across neighboring countries – with Greece as a major part of the value-added chain – also face valuable opportunities for FDI in some of the accession countries. There is, however, a caveat, namely that Greece traditionally has not been a major source country of FDI in Europe. For this reason it is unclear whether rising Greek outward vertical FDI could counterbalance the impact of rising import competition from eastern Europe.

A particular challenge is in the field of economic policy. Here, it will be interesting to define which opportunities the Community has to improve policy effectiveness and policy efficiency at the supranational level. Moreover, one might have to raise the question of whether stricter reporting standards for national and regional subsidization should not be imposed. At the same time one will have to look at the drawbacks of an oversized agricultural EU budget in a period in which the logic of economic globalization calls on the enlarged EU to specialize more on technology intensive goods. The very low R&D budget of the Community deserves critical attention in this respect.

## Appendix A: Statistical Measures of Structural Change

According to STAMER (1999) the degree of structural change between the time points or time periods, respectively, 1 and 2 can be measured by the following indicators (for output X) if we distinguish sectors  $i = 1 \dots n$ ,

$$\sum_{i=1}^n X_i = X \quad (1)$$

and  $(x_i = \frac{X_i}{X})$

$$\sum_{i=1}^n x_i = 1 \quad (2)$$

1. Norm of absolute values (*NAV*):

$$NAV_{1,2} = \sum_{i=1}^n |x_{i2} - x_{i1}| \quad (3)$$

2. Euclidean norm (*EuN*):

$$EuN_{1,2} = \sqrt{\sum_{i=1}^n (x_{i2} - x_{i1})^2} \quad (4)$$

3. Sum of relative differences' absolute values (*SRD*):

$$SRD_{1,2} = \sum_{i=1}^n \left| \frac{x_{i2} - x_{i1}}{x_{i1}} \right|, \quad x_{i1} > 0 \quad (5)$$

4. Information gain (*IG*):

$$IG_{1,2} = \sum_{i=1}^n x_{i2} \ln \left| \frac{x_{i2}}{x_{i1}} \right|, \quad x_{i1} > 0, \quad x_{i2} > 0 \quad (6)$$

5. Growth rate parameter (*GRP*):

$$GRP_{1,2} = \sum_{i=1}^n x_{i1} |g_{i2} - g_2|,$$

that is with  $g_{i2} = \ln X_{i2} - \ln X_{i1}$ ,  $g_2 = \ln X_2 - \ln X_1$  (7)

$$GRP_{1,2} = \sum_{i=1}^n x_{i1} \left| \ln \frac{x_{i2}}{x_{i1}} \right|, \quad x_{i1} > 0, \quad x_{i2} > 0.$$

6. LILIEN Index (*LI*) (see LILIEN, 1982a, b):

$$LI_{1,2} = \sqrt{\sum_{I=1}^n x_{i2} \left( \ln \frac{x_{i2}}{x_{i1}} \right)^2}, \quad x_{i1} > 0, \quad x_{i2} > 0. \quad (8)$$

7. The modified LILIEN Index (*MLI*) (see STAMER, 1999, p. 42-44):

$$MLI_{1,2} = \sqrt{\sum_{I=1}^n x_{i1} x_{i2} \left( \ln \frac{x_{i2}}{x_{i1}} \right)^2}, \quad x_{i1} > 0, \quad x_{i2} > 0. \quad (9)$$

Some important features of these indicators of structural change are summarized in table 1. Note that the first three properties are necessary (and sufficient) conditions for an indicator to be a metric space (see CHIANG, 1984, p. 73-75).

**Tab. 1: Features of structural change's indicators**

	Zero distance in case of identity	Symmetry in respect of time direction	Fullfilment of trangular inequality	Measure of dispersion	Consideration of sector's weights
Norm of absolute values	yes	Yes	yes	no	yes
Euclidean norm	yes	Yes	yes	no	yes
Sum of relative differences' absolute values	yes	No	no	yes	no
Information gain	yes	No	no	no	yes
Growth rate parameter	yes	No	no	yes	yes
LILIEN Index	yes	No	no	yes	yes
Modified LILIEN Index	yes	yes	yes	yes	yes

Source: STAMER (1999), p. 53.



All indicators mentioned above have advantages and drawbacks; the choice of an indicator has to be made on the basis of the goals of the respective research. For many purposes, the norm of absolute values and/or the Euclidean norm are frequently used measures. A useful indicator as a measure of diversification is the index proposed by LILIEN (1982a). Some drawbacks of this indicator are remedied by the Modified LILIEN Index of STAMER (1999). This, however, comes at the cost of a more complex interpretation.

## Appendix B: Measures of Specialization

If one wants to assess competitiveness in an economic or technological (Schumpeterian) perspective it is useful to calculate some specialization indicators. Most indicators are based on Balassa's "Revealed Comparative Advantage" index (BALASSA, 1966). Often, some modifications are used to yield a symmetric version of this indicator. Following this approach, the specialization for a variable of interest  $Z_{ij}$  for sector  $i$  in country  $j$  is measured as "Relative Z Share" ( $RZS$ ):

$$RZS_{ij} = 100 \tanh \ln \left[ \left( \frac{Z_{ij}}{\sum_i Z_{ij}} \right) / \left( \frac{\sum_j Z_{ij}}{\sum_i \sum_j Z_{ij}} \right) \right].$$

The logarithm is used to yield a symmetric version and the hyperbolic tangent is used to constrain the indicator on a range  $-100$  and  $+100$ . An indicator  $RZS_{ij}$  above zero indicates that country  $j$  is positively specialized in sector  $i$ , while a  $RZS_{ij}$  below zero indicates a negative specialization. In the empirical applications  $Z$  stands either for  $P=Patents$ ,  $Y=Value Added$  or  $X=Exports$ .

Similarly to the original Balassa  $RCA$  index, a (net) foreign trade  $RCA$  can be defined, which takes also the competition on home markets into consideration. It is given by

$$RCA_{ij} = 100 \tanh \ln \left[ \left( \frac{X_{ij}}{M_{ij}} \right) / \left( \frac{X_j}{M_j} \right) \right],$$

where  $M_{ij}$  represents imports of sector  $i$  in country  $j$ . This index is also bounded between  $-100$  and  $+100$ . Here, a value of  $RCA_{ij}$  above zero implies that the country considered  $j$  has a trade balance position above the national average in sector  $i$ , while a value below zero implies a sector trade balance below the national average.

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