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Technological Activities in CEE Countries: A Patent Analysis for the Period 1980-2009*

Abstract

The aim of this paper is to analyze the technological activities of Central and Eastern European (CEE) economies and to compare them with the technological activities of other world regions. Using data from the EPO World Wide Statistical Database for the period 1980-2009 the analysis is based on counts of priority patent applications over time. In terms of priority patent applications, CEE reduced its technological activities drastically in absolute and per capita terms after 1990. The level of priority patent applications in this world region maintained more recently a stable level below the performance of EU15, South EU and the former USSR. In what concerns technological specialization, the results suggest a division of labor in technological activities among world regions where Europe, Latin America and the former USSR are mainly specializing in sectors losing technological dynamism in the global patent activities (Chemicals and/or Mechanical Engineering) while North America, the Middle East (especially Israel) and Asia Pacific are increasingly specializing in Electrical Engineering, a sector with strong technological opportunities.

Keywords: CEE, patent indicators, priority counts, patstat, trends, specialization

JEL Classification: O30, O57

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1. Introduction

The aim of this paper is to analyze the technological activities of CEE economies in the period 1980-2009 and to compare them with the technological activities of other world regions and European economies. The main research questions are:

1) How have CEE economies performed technologically in the period 1980-2009 compared to other world regions?
2) On which technological sectors and on which technologies are CEE economies specializing currently?
3) Are the technological activities of European economies converging in terms of performance and specialization?

The analysis draws on patent indicators. Patent indicators have a large tradition in the analysis of technological innovation and extensive research has already been done using them for the comparative analysis of technological development across countries and sectors (Archibugi 1992; Nesta and Patel 2013; OECD 2009).

Patents give patent applicants exclusive rights to commercially exploit a technological invention for a limited period of time in a certain country. Archibugi(1992) stresses that patents represent a technological capability but are most appropriate to capture those technological capabilities with a business potential. Among all inventions applied for patent protection there are technological activities involving incremental technological development (and rather lower international market perspective) and activities pushing the technological frontier, which are usually of higher market value. Developing and catching up regions are usually far away from the technological frontier and catch up technologically mainly through imitative learning. Patent indicators to a large extent underestimate the technological capabilities of regions catching up technologically. The underestimation is even larger if patent statistics consider foreign patent applications only (counts of patents or patent applications in a foreign country, which are usually of higher market value). In the case of CEE economies there has been a significant disparity between domestic and foreign patenting, domestic patenting being much larger than foreign patenting since patent protection in local markets has been traditionally more important. Empirical research on technological activities in CEE economies acknowledges that foreign patents (patent applications of CEE actors in a foreign country) are a misleading indicator as far as domestic technological capabilities in CEE are concerned (Marinova 2001).

Interestingly, the body of empirical research done so far on CEE economies uses mainly US Patent data to analyze technological development before and during the transition period from planned to market economies. For instance, Radosevic and Kutlaca (1999) use US Patents per capita to analyze patenting activity of CEE in the US in the period 1969-1994. Their data suggest these countries were comparable to the four less developed EU economies and the newly industrialized economies (Taiwan, Ireland, South Korea, Mexico and Brazil) as far as patenting activity is concerned. While in the 1970s patenting activities in terms of US Patents increased compared to the less developed EU countries and other economies with comparable income, in the 1990s it fell sharply. Only in Hungary and in the ex-Yugoslavia (Croatia and Slovenia) patenting activity remained above the levels of the 1970s. In terms of specialization, the technological advantages of CEE economies were based in metallurgical and mechanical technologies as well as in chemicals/drugs. Marinova (2001) considers the period 1976-1999 to compare patenting activities of formerly planned economies with OECD countries using US Patents as well. Again, her analysis suggests that CEE economies experienced a decrease in their patenting activities in the 1990s. The gap between CEE economies and developed market economies was quite significant. Hungary was the leading CEE country in terms of patents per capita. Also Slovenia shows a relatively positive trend in the patenting activities. In terms of technological specialization, Marinova analyzes 18 industrial sectors as defined by the US Patent and Trademark Office Database. She points out that in the period considered CEE countries had a technological strength in the fields of "petroleum, coal and chemicals". More recently, also drawing on US patents, Lengyel et al. (2013) study the geographical distribution technological activities in CEE economies. Their analysis suggests that in CEE countries inventors tend to agglomerate in selected regions as is the case in western economies. Moreover, by identifying cross-border interactions in patent applications (considering different national locations of patent assignees and inventors), the results suggest a strong role played by foreign multinationals in the indigenous technological activities of CEE economies.

These contributions using US Patent data capture the technological activities being carried out in CEE with higher market value. We interpret these inventions protected by patents in foreign countries as the ones pushing the world technological frontier. In order to make a comprehensive analysis of technological activities in CEE economies both types of activities need to be considered: activities at the technological frontier with strong international market perspective as well as those with lower international business potential protected in the home country. For this purpose this contribution develops patent indicators for CEE economies based on the worldwide count of **priority patents** (de Rassenfosse et al. 2013). The data used and the methodology applied are described in the next section. After identifying the technological opportunities developing in different technologies and technological sectors, the analysis will compare CEE with other world regions in terms of counts of priority patents, patent intensity (priority patents per capita) and technological specialization. Next, the analysis will concentrate on the technological activities of CEE economies at the national level. By using priority patents, the results should give a more precise and real view of the technological capabilities of CEE economies than the existing studies based on US patents.

2. Data and Methods

To capture national technological capabilities in a more comprehensive way than research contributions have done so far, we develop patent indicators based on counts of priority patent applications filed by a country's inventors (no matter in which patent office the priority patent has been filed). A priority filing is the first patent application filed to protect an invention The methodology draws on de Rassenfosse et al.(2013). We use data from the Worldwide Patent Statistical Database (PATSTAT, October 2012). The advantage of counting priority patents of a country's inventors against other patent counting methodologies mainly focusing on high-value patents (such as US patent counts, transnational patent counts or triadic patent families) lies on the indicators capturing "the inventiveness of countries" rather than their "inventive performance" (de Rassenfosse, Dernis, Guellec, Picci, & van Pottelsberghe de la Potterie 2013). "Inventiveness" relates to the success of countries in engaging in technological activities and applying for patents to protect their inventions while "inventive performance" involves the assessment of patenting activities with high-value patent indicators. We replicate the data generated by de Rassenfosse et al (2013) and develop indicators for CEE, selected world regions and carry out a technological specialization analysis.

One important bias of the indicator for the purpose of comparing the technological capabilities of CEE economies with other world regions and countries relates to the institutional differences across patent offices. Especially in the case of Japan, the Japanese IP framework seems to inflate the counts of priority patents of Japanese inventors. Recently changes in the US patent system have led to bias towards trivial patents which transformed the patent system 'from a shield that innovators could use to protect themselves, to a grenade that firms lob indiscriminately at their competitors, thereby increasing the cost and risk of innovation rather than decreasing it' (Jaffe and Lerner, 2006:2). As they point out 'the weakening of examination standards and the increase in patent applications has led to a dramatic increase in the number of patents granted in the U.S' (ibid, p.3). However, as the overall effects of this bias are not yet clear we interpret US patents data at their face value. Also, our time horizon of analysis extends well before these changes.

In overall, this institutional bias needs to be taken into account when making cross country comparisons between countries with radically different Intellectual Property (IP) frameworks or different national propensities to patent. Another important bias of the indicators relates to the methodology applied to assign a country of origin to each invention. As already mentioned, the technological capabilities of a country are measured in terms of worldwide priority patents of the country's inventors. The assignment of a country to each invention relies hence on the availability of information on inventors' location. However, the availability of such information varies across patent offices in the PATSTAT database. Coverage problems where found for five countries: Australia, Chile, Denmark, India and Ireland. The indicators for CEE countries are very accurate.

Priority patents are counted for the priority years 1980 to 2009. The country time series are computed following the "whole count" methodology if inventors from different countries contribute to one invention. In other words, if a priority patent includes one inventor from Germany and one from USA, one priority count is consider for each country. The time series for world regions (including groups of countries) are computed avoiding multiple counting if an invention includes inventors from different countries belonging to the same region.[1]

Following the methodology of the WIPO (2013), the technological profiles of the world regions and countries across 5 technological sectors (Chemicals, Electrical Engineering, Mechanical Engineering, Instruments, Others) and 35 technologies are computed according to the WIPO IPC-technology concordance table as updated in 2011[2]. The concordance table draws on the classification put forward by Schmoch (2008). The assignment of an invention to a technological sector or specific technology field follows a fractional counting methodology.[3]

The study considers whether the technological specialization of countries and regions is enabling them to enter into the dynamic sectors at the technological frontier or whether technological knowledge is being generated in stagnant fields.

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[1] If a priority patent includes inventors from Germany and France the priority patent application will be one patent count for EU15.

[2] The WIPO IPC-technology concordance table is available at: http//www.wipo.int/ipstats/en (last Accessed on September 2013)

[3] If a priority patent application includes patent classes that belong to different technological areas or technologies a fraction (and not a whole count) will be considered for each technological area or technology.

Table 1. Priority fillings in 35 technology fields and 5 technological sectors in three time periods.

		Technological Class	1980 - 1989		1990 - 1999		2000 - 2009		Technological dynamism*
			Priority Fillings	Share	Priority Fillings	Share	Priority Fillings	Share	
Electrical engineering	1	Electrical machinery, apparatus, energy	321366,6	7,4	331415,8	6,6	473833,9	6,7	-0,63
	2	Audio-visual technology	241570,2	5,5	306932,2	6,1	391623,8	5,6	0,03
	3	Telecommunications	124966,2	2,9	190361,1	3,8	298377,9	4,2	1,38
	4	Digital communication	30386,9	0,7	65634,0	1,3	201726,2	2,9	2,17
	5	Basic communication processes	86753,9	2,0	68877,1	1,4	69614,0	1,0	-1,00
	6	Computer technology	201164,7	4,6	282465,0	5,6	511834,7	7,3	2,66
	7	IT methods for management	4488,8	0,1	15083,8	0,3	109046,3	1,5	1,45
	8	Semiconductors	159450,6	3,6	218791,9	4,3	332141,9	4,7	1,07
			1170147,9	**26,8**	**1479561,0**	**29,4**	**2388198,8**	**33,9**	**7,13**
Instruments	9	Optics	207140,9	4,7	271023,5	5,4	341941,6	4,9	0,12
	10	Measurement	277080,3	6,3	240621,3	4,8	302920,5	4,3	-2,04
	11	Analysis of biological materials	16259,7	0,4	17258,0	0,3	27691,2	0,4	0,02
	12	Control	91597,7	2,1	98901,9	2,0	134153,4	1,9	-0,19
	13	Medical technology	94290,0	2,2	137712,9	2,7	216675,2	3,1	0,92
			686368,7	**15,7**	**765517,6**	**15,2**	**1023381,8**	**14,5**	**-1,18**
Chemistry	14	Organic fine chemistry	87404,4	2,0	79898,0	1,6	107746,4	1,5	-0,47
	15	Biotechnology	29931,0	0,7	37310,9	0,7	75064,6	1,1	0,38
	16	Pharmaceuticals	35413,0	0,8	55453,7	1,1	138321,1	2,0	1,15
	17	Macromolecular chemistry, polymers	81738,2	1,9	90763,5	1,8	94512,8	1,3	-0,53
	18	Food chemistry	47867,5	1,1	63979,9	1,3	130128,7	1,8	0,75
	19	Basic materials chemistry	97531,3	2,2	108091,7	2,1	139877,3	2,0	-0,25
	20	Materials, metallurgy	165410,5	3,8	135505,9	2,7	153181,9	2,2	-1,61
	21	Surface technology, coating	90285,1	2,1	96824,6	1,9	116281,2	1,7	-0,42
	22	Micro-structural and nano-technology	53,8	0,0	1380,2	0,0	10100,8	0,1	0,14
	23	Chemical engineering	129184,6	3,0	119713,2	2,4	136989,6	1,9	-1,01
	24	Environmental technology	59623,3	1,4	88530,0	1,8	119325,0	1,7	0,33
			824442,8	**18,9**	**877451,6**	**17,4**	**1221529,5**	**17,3**	**-1,52**
Mechanical Engineering	25	Handling	168746,4	3,9	193068,9	3,8	207124,9	2,9	-0,92
	26	Machine tools	226146,5	5,2	176591,9	3,5	189465,9	2,7	-2,49
	27	Engines, pumps, turbines	159187,2	3,6	149469,5	3,0	204180,3	2,9	-0,74
	28	Textile and paper machines	141869,8	3,2	152840,5	3,0	167281,4	2,4	-0,87
	29	Other special machines	198077,3	4,5	207533,3	4,1	229915,8	3,3	-1,27
	30	Thermal processes and apparatus	120637,3	2,8	117976,3	2,3	146668,2	2,1	-0,68
	31	Mechanical elements	144561,9	3,3	161542,4	3,2	211149,9	3,0	-0,31
	32	Transport	162552,6	3,7	230543,8	4,6	341477,3	4,8	1,13
			1321779,0	30,3	1389566,8	27,6	1697263,8	24,1	-6,15
Other fields	33	Furniture, games	80452,6	1,8	145690,0	2,9	245555,5	3,5	1,65
	34	Other consumer goods	79937,0	1,8	117266,5	2,3	166222,7	2,4	0,53
	35	Civil engineering	205662,1	4,7	257178,7	5,1	298928,9	4,2	-0,46
			366051,7	**8,4**	**520135,1**	**10,3**	**710707,2**	**10,1**	**1,71**

* Difference between the shares in the first and last period (1980-1989 and 2000-2009).
Technology class definition according The WIPO IPC-technology concordance table available at: http//www.wipo.int/ipstats/en (last Accessed on September 2013)
Source: PATSTAT, October 2012. Authors calculations.

As an estimator of the technological dynamism of technologies and technological sectors we adopt the approach of Kropacheva and Molero (2013) calculating the difference between the share that each field has in the total priority patent output in the period 2000-2009 and the same share in the period 1980-1989. Table 1 gives the data for calculating this indicator for 35 technology fields and 5 technology sectors.

The last column includes the indicator for technological dynamism. The technological sector "Electrical Engineering" holds the largest volume of priority patents in the period 2000-2009. The share of priority patents in this technological sector increased from 26,8% in the period 1980-1989 to 33,9% in the period 2000-2009. This technological sector experiences a strong relative growth in the overall patenting activities suggesting the presence of technological opportunities. The sector "Other fields" (which includes consumer goods and civil engineering) is also gaining relative importance especially in the field "Furniture and Games". Interestingly, the sector "Mechanical Engineering", which holds traditionally a large share in the overall patenting activities, has reduced its share of priority patents in the overall patenting activities which can be interpreted as a relatively declining technological opportunities in this sector. The same holds for the sectors "Chemicals" and "Instruments". Apart for some exceptions (such as "Pharmaceuticals", "Food Chemistry", "Nano-technology" and "Medical Technology"), the technological fields in these sectors are stagnating in terms of technological dynamism compared to other fields. The data suggest that the sector "Electrical Engineering" (especially in the fields of "computer technology" and "digital telecommunication") is accumulating potential for technological development and commercialization while "Mechanical Engineering" (especially in the fields of "Machine Tools" and "Special Machines") is a relatively stagnant area. "Transport" is the only technology field with increasing technological opportunities in the "Mechanical Engineering" sector.

3. Patenting activities in world regions

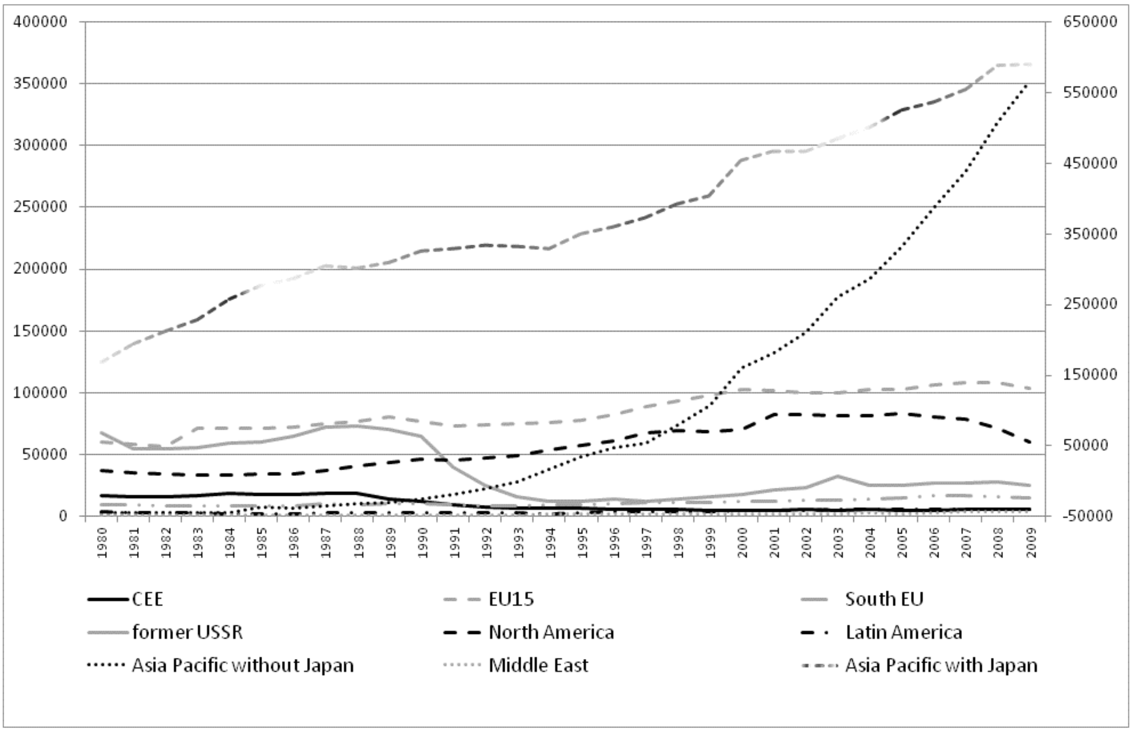
This section compares the patenting activities of CEE as a region with other 7 regions: EU15, South EU, North America, Middle East, Asia Pacific, Latin America and former USSR[4]. The analysis presents firstly general trends for the period 1980-2009 based on the absolute number of priority patents in each world region and on the patent intensity (number of priority patent applications per capita). Moreover, the trend analysis is complemented with the study of the technological specialization of each region and the changes in specialization over time. The section concludes with convergence analysis between world regions and the CEE by means of a Structural Deviation Indicator (SDI).

[4] A part of South EU (all countries except Malta and Cyprus) is also included in the EU15. We make this distinction as we find it very relevant to compare CEE with the EU15 as a group as well as with the South EU as comparable group of the EU periphery. However, EU15 and South EU are never double counted.

3.1 General trends

Figure 1 gives the time series of priority patent applications for 9 world regions[5] for the years 1980-2009. Interestingly the number of priority patents assigned to Asia Pacific is by far the largest and about 6 times larger than the next larger region EU15 in the year 2009 (values for Asia Pacific are given in the right hand axis). The region Asia Pacific includes data for Japan, China and Korea among other countries. These three countries hold more than 90% of the region's priority patent applications. Due to the institutional bias in the data for Japan pointed out in section 2, the data for Asia Pacific has been given with and without Japan[6].

Figure 1. Priority patents in world regions (1980-2009)



Source: PATSTAT October 2012. Authors calculations

The data suggest these main trends:

- CEE experiences a decrease in patent activities at the end of the 1980s and do not recover. The activities remain quite stable below the level of South EU.

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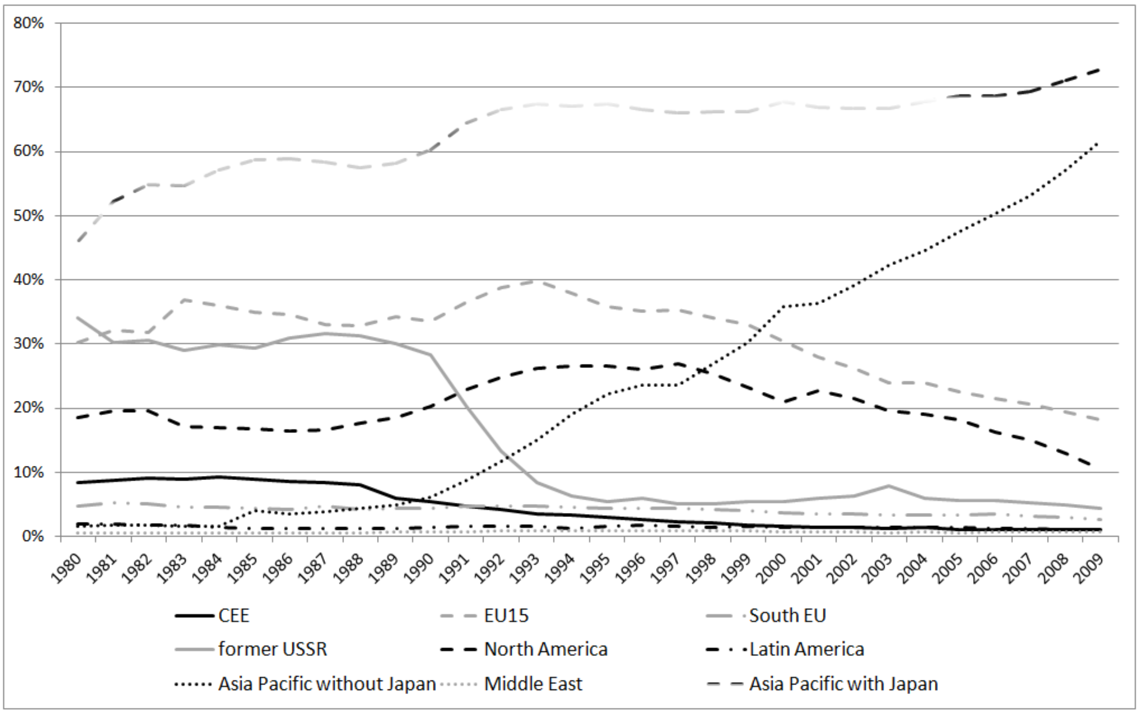
[5] The countries included in every world region are listed in the Annex.

[6] The Data for Asia Pacific hides almost exclusively the technological activities of Japan, China and Korea. In the period 1980-1989, 98% of the patents appointed to the region Asia Pacific belong to Japan. China and Korea are the follower top economies in this region holding 2% of the region. In the period 2000-2009 Japan holds 58.3% of the regional share in Asia Pacific followed by China (18%) and Korea (17,9%).

- Asia Pacific is in absolute terms the strongest region in the number of priority patents even if we eliminate Japan. In the 1990s, China and Korea have increased their technological activities notably compared to the countries in the other world regions which suggest strong catching up in terms of absorptive capability.
- EU15 is the second strongest world region followed quite closely by North America in terms of absolute number of priority patents in the period 1980-1999. However, EU15 seems to be able to maintain the level of patent applications after 2005 while North America's annual level decreases slightly.
- The former USSR experiences a strong decrease in the number of priority patent applications after 1990 and recover only slightly at the end of 1990s. However, their level stays above the CEE achievement.

Figure 2. Share of priority patents by world regions 1980-2009

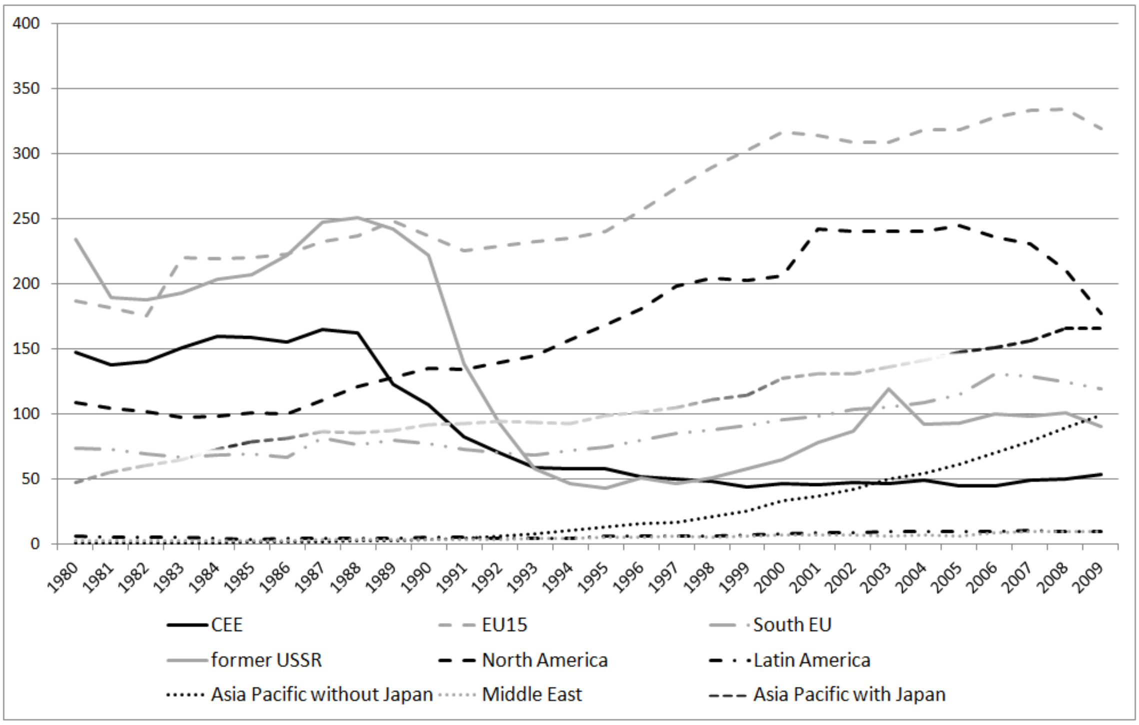


Source: PATSTAT October 2012. Authors calculations

Figure 2 gives the share of priority patents held by each world region. In this figure the weight of Asia Pacific in the world patenting activity in terms of priority patents is clear. Asia Pacific seems to have rapidly increased patenting activities since the early 1990s while EU15 and North America have been losing their shares at the same pace.

The per capita data given in Figure 3 qualifies the rank of countries in terms of patent activities. However, the trends over time do not vary. Accordingly, after 1990 EU15 becomes the lead region in terms of priority patents per capita followed by North America and South EU after 1990 (when the former USSR clearly reduces the number of priority patents). The overall trends described in terms of absolute number concerning Asia Pacific (with and without Japan), the former USSR and CEE hold as well for the per capita indicators. The recovery of the fUSSR after 1998 is quite clear. All in all, CEE seems to have reduced its patenting activities drastically after 1990 and maintains now a stable level below the performance of EU15 and South EU and the former USSR.

Figure 3. Patent intensity (priority patents per capita) 1980-2009



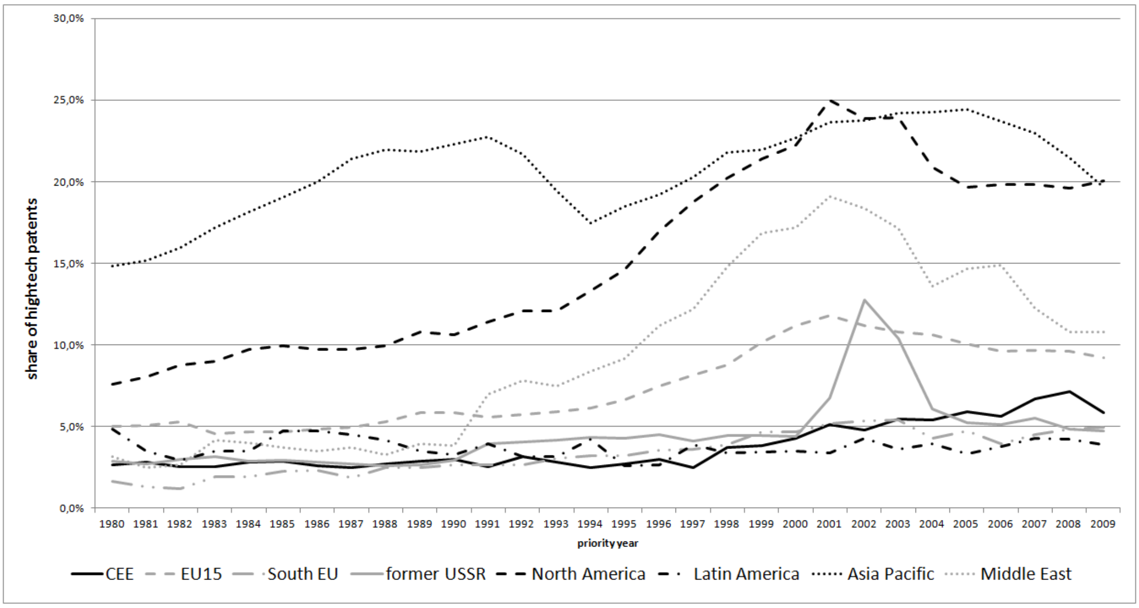
Source: PATSTAT October 2012. Authors calculations

The shares of priority patent applications in High-Technology fields in the total regional outputs for the period 1980-2009 are given in figure 4. [7] Clearly in Asia Pacific, North America and in the Middle East high technology fields hold larger shares in the total patent output than in the other world regions. Especially in North America the share

[7] Eurostat-Hightech-Definition as given under http://epp.eurostat.ec.europa.eu/cache/ITY_SDDS/Annexes/pat_esms_an8.pdf (last accessed on April 2013)

increased continuously between 1989 and 2001 to reach the 21% peak above the share in Asia Pacific. Both regions have experienced recently a decline in the importance of High-Technology in their patenting activities which held in 2009 20% of the total patenting output of the respective region. Interestingly, even though EU15 holds traditionally a relatively low patent share of high-technology patents in its total output (bellow 10% in average for the whole period), this share increased notably to reach a level above 10% in the early 2000s. However, it is declining after reaching that peak. In CEE this share started to increase from 2.5% in 1997 to reach 7% in 2008. In 2009 the share declines to 6%. In Latin America and in South EU the share of high-technology patents in the total regional patent output has been below 5% for the entire period.

Figure 4. Share of priority patent applications in High-Technology fields. 1980-2009



Source: PATSTAT October 2012. Authors calculations

3.2. Technological specialization of world regions

To explore the technological specialization of world regions and countries we adapt the 'Revealed Comparative Advantage' measure, originally created by Balassa (1965) to produce export performance indices for specialized sectors of countries. In the context of technology analysis it was first introduced by Soete and Wyatt (1983) as RTA – Revealed Technological Advantage index and since then has been successfully used in the patent analysis to examine specialisation in technology fields (Pavitt and Patel, 1988; Meyer, 2006; Frietsch and Schmoch, 2010; Chen, 2011; Zheng et al, 2011).

The index is set up as follows:

$$RTA_j^i = \frac{\left(\frac{P_j^i}{P_j}\right)}{\left(\frac{P_{world}^i}{P_{world}}\right)}$$

Where:

RTA^i_j = Revealed Technological Advantage index based on priority patents in field i of country j;
P_j^i = patents in field i of country j;
P_j = Patents in all fields of country j;
P^i_{world} = world patents in field i;
P_{world} = world patents in all fields.

This indicator allows capturing the relative technological specialization of a country or world region vis-à-vis the specialization of the world.[8] Table 2 presents 5 technological sectors (Chemicals. Electrical Engineering, Mechanical Engineering, Instruments and Other fields) in the 8 world regions we are considering classified as Sectors of Continuous Advantages, Newly Gained Advantages, Sectors of Lost Advantages and Sectors of Continuous Disadvantages. The classification is based on the Revealed Technological Advantage (RTA) of each world region in the respective technological sector and on the shifts in the RTA values over two periods. The aim of this classification is to capture changes in the specialization profiles of countries and regions over time. Moreover, the analysis aims to identify on the one hand the technological sectors and technologies where regions and countries have traditionally being engaged on, accumulating capabilities and most likely pushing the technological frontier and, on the other hand, technologies where regions are starting to specialize, creating absorptive capacity in novel technological fields for the region. Accordingly, technological sectors are classified as:

- "Continuous Advantages" if they display a RTA>1 in both periods under consideration),
- "Newly Gained Advantages" if they display a RTA>1 in the recent period and RTA < 1 in the oldest period,
- "Lost Advantages" if they display a RTA<1 in the recent period and RTA > 1 in the oldest period and
- "Continuous Disadvantages" if RTA <1 in both periods.

[8] The Annex includes graphs illustrating RTA indicators across 35 technologies of CEE countries, benchmark countries, and 8 world regions in two periods.

Table 2: Shifting areas of RTA in World Regions (5 technological sectors) 1980-89/2000-09

	RTA >1 (1980-89) (traditional advantages)	**RTA <1 (1980-1989)** (traditional disadvantages)
RTA >1 (2000-09) (new advantages)	***CEE:*** chemicals, mechanical eng. ***EU15:*** mechanical eng., other fields* ***South EU:*** chemicals, mechanical eng., other fields* ***Former USSR:*** instruments, mechanical eng. ***North America:*** instruments ***Asia Pacific:*** electrical eng.* ***Latin America:*** mechanical eng., other fields* ***Middle East:*** instruments **Sectors of continuous advantages (14)**	***CEE:*** other fields* ***EU15:*** - ***South EU:*** - ***Former USSR:*** chemicals ***North America:*** electrical eng.* ***Asia Pacific:*** - ***Latin America:*** chemicals ***Middle East:*** electrical eng.* **Newly gained advantages (5)**
RTA <1 (2000-09) (new disadvantages)	***CEE:*** - ***EU15:*** chemicals ***South EU:*** - ***Former USSR:*** other fields* ***North America:*** chemicals, other fields* ***Asia Pacific:*** - ***Latin America:*** - ***Middle East:*** chemicals, other fields* **Sectors of lost advantages (6)**	***CEE:*** electrical eng.*, instruments ***EU15:*** electrical eng.*, instruments ***South EU:*** electrical eng.*, instruments ***Former USSR:*** electrical eng.* ***North America:*** mechanical eng. ***Asia Pacific:*** instruments, chemicals, mechanical eng., other fields* ***Latin America:*** electrical eng.*, instruments **Middle East:** mechanical eng. **Sectors of continuous disadvantages (15)**

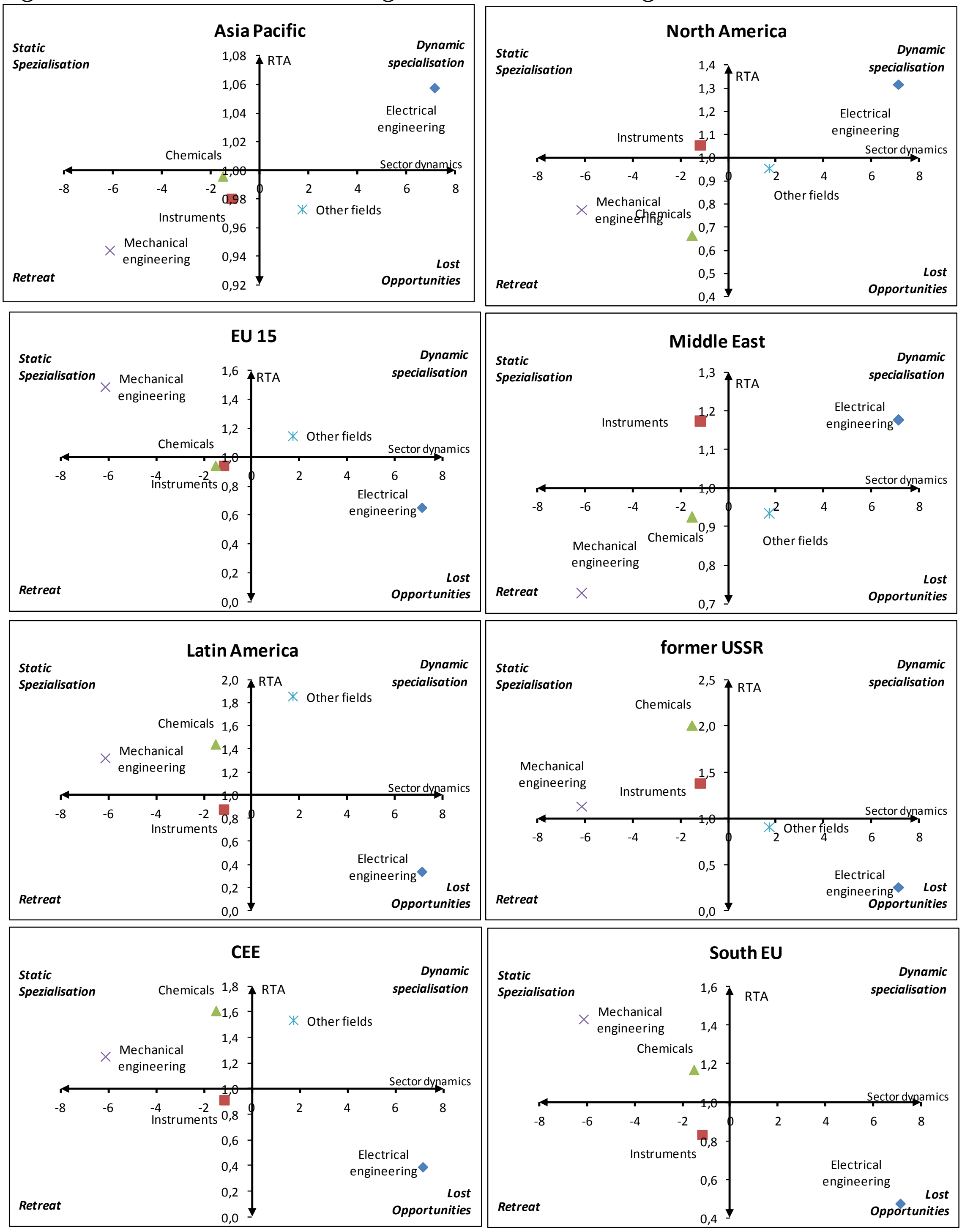
*Indicator for technological dynamism >0 (See Table 1)

The consideration of the RTA indicators in two time periods 1980-1989 and 2000-2009 suggests a quite persistence in the technological specialization of regions since 1980. For most regions the technological sectors can be classified either as sectors of Continuous Advantages or as sectors of Continuous Disadvantages, which means that changes in the technological specializations of regions are minor. This finding is not surprising if we consider the cumulative and area specific nature of technological development. Especially the profiles of South EU and Asia Pacific remain rigid in terms of technological specialization. A weak shift in the specialization profile can be observed in certain regions towards Chemicals (former USSR and Latin America) and towards Electrical Engineering (North America and Middle East). These shifts speak for diversification towards new technological sectors for the respective region.

"Chemicals" and "mechanical engineering" are traditional sectors of technological activities in CEE, EU15 and South EU. The focus on "Chemicals" seems to become weaker in EU15 in the period 2000-2009. On the other hand, “Electrical Engineering” is a sector of continuous disadvantages in Europe as well as in the former USSR and Latin America.

Figure 5 gives the specialization profiles of the different world regions in the period 2000-2009 combined with the technological dynamism of the sectors between 1980-1989 and 2000-2009. Considering the technological dynamism of the different fields as given by the indicator presented in table 1, the division of labor among world regions suggests that Europe, Latin America and the former USSR are mainly specializing in sectors of relatively declining technological dynamism in the global patent activities (Chemicals and/or Mechanical Engineering). Interestingly, in CEE, South EU and EU 15 the sector “Other fields”, which includes the technological fields “Consumer Goods and “Civil Engineering” and is a dynamic technological sector, plays an important role in the technological profile of these regions. On the other side, North America, the Middle East (especially Israel) and Asia Pacific are increasingly specializing in “Electrical Engineering”, the sector with strong technological opportunities. These regions are broadening their technological capabilities and are increasing absorptive capacity in the dynamic technological fields at the technological frontier. In overall, there seems to be global division of labor whereby EuroAsia (EU and fUSSR) is more specialized in chemicals and mechanical engineering (sectors losing technological dynamisms) while Pacific (North America and Asia Pacific) are more specialized in the most dynamic sector (electrical engineering).

Figure 5: Classification of technological sectors in world regions 2000-2009



Source: PATSTAT October 2012. Authors calculations

Table 3 allows for a closer look at the shifts in RTA and technological dynamisms of 35 technology fields in the different world regions.

As already mentioned, in CEE Chemicals and Mechanical Engineering are the technological sectors of Continuous Advantages. The data suggest that, as other world regions, CEE countries are mostly accumulating technological knowledge in stagnant technological sectors. However, there are some regional differences if we take a closer look at the technology fields in Chemicals (see Table 3). In general terms, CEE holds a Continuous Advantage together with South EU in the **Chemicals** sector. Taking a look at the technology fields "Micro-structural and Nano-technology", a dynamic technology field increasing its share in the overall patenting output as indicated by the technological dynamism indicators, are becoming a new advantage for CEE. South EU (and in these technologies also EU15) have a Continuous Advantage in stagnant areas such as "Organic Fine Chemistry", and "Chemical Engineering". However, it has also gained specialization in more dynamic chemical fields such as "Biotechnology" and "Environmental Technology". These technologies seem to be an important focus for technological activities in Europe. In what concerns the former USSR, it is diversifying towards chemicals, which again suggest a focus on stagnant technological fields. However, chemical technologies with a New Advantage in the fUSSR also include "Pharmaceuticals", "Biotechnology" and "Microstructural- and Nanotechnology", which are fields experiencing technological dynamism. Accordingly, even though South Europe, CEE countries and the former USSR are accumulating knowledge in relatively stagnant technological sectors, there are some exceptions that suggest the ability of these regions to generate knowledge in dynamic technology fields. Interestingly, North America has lost Advantage in Chemicals. The focus has been decreasing on all Chemical technologies except for "Surface Technology and Coating".

The sector **Mechanical Engineering** is characterized by a strong stagnation in technological opportunities. Except for the technology field "Transport", all technology fields are slowing down the rate of creation of technological opportunities. In the European regions considered (CEE, EU15 and South EU), in the former USSR and in Latin America Mechanical Engineering is a Sector of Continuous Advantage. These regions are traditionally specialized in this technological sector. However, there are some regional differences if we take a closer look at the technology fields. The specialization of CEE is persistent in "Handling", "Machine Tools", "Other special machines", and "Mechanical elements". At the same time specialization has been reduced in "Textiles and paper Machine Technologies" and has increased in "Engines, Pumps and Turbines" (see Table 3). All these sectors have lost technological dynamism. On the other hand, CEE shows an increasing specialization in "Transport", the only technology field in this sector with increasing technological dynamism. South EU is focusing on Mechanical Engineering technologies. Interestingly this region is the only region together with Asia Pacific with a Continuous Advantage in “Textile and paper machines”, a technological field losing importance in the overall patent output. Together with the EU 15 and Latin America, the region has a traditional focus on “Transport”. EU15 is losing advantage in “Thermal Processes and Apparatus” and shows a Continuous Disadvantage in “Textile and Paper Machines”. The former USSR has also Continuous Disadvantage in “Textile and paper machines” as well as in “Transport”.

After analyzing the sectors where CEE holds a Continuous Advantage (Chemicals and Engineering) we proceed to take a look at those sectors of Continuous Disadvantage over time for CEE: “Electrical Engineering” and “Instruments”, both sectors including fields of strong technological dynamism. This continuous disadvantage is common to all technologies in **“Electrical Engineering”.** EU15, South EU, the former USSR and Latin America experience a Continuous Disadvantage in this technological sector as well. Only EU15 is newly focusing on “Digital Communication”. North America and the Middle East are diversifying towards Electrical Engineering where the focus on some Information and Communication Technologies is increasing. Asia Pacific is the only region continuously focusing on “Electrical Engineering”. However, this region has lost Advantage in specific “Electrical Engineering” technologies such as “Digital Communication”, “Basic Communication Processes”, and “Computer Technology” which means that its RTA are now very strongly and narrowly confined on “Telecommunication”, “Audio visual Technologies” and “Electrical machinery, apparatuses and Energy” (see Table 3).

The Sector of **Instruments** is a Sector of Continuous Disadvantage in all European regions, as well as in Asia Pacific and Latin America. In CEE some Instrument-technologies have strong weight in the regional technological profiles: “Measurement” and “Analysis of Biological Materials”. Surprisingly all world regions except for Asia Pacific have a Continuous Disadvantage in “Optic technologies”. North America, Middle East and the former USSR display a Continuous Advantage in the sector of “Instruments”.

Finally, CEE is diversifying towards the sector of **“Other fields”,** which includes Consumer Goods and Civil Engineering technologies. Technological activities in this sector in CEE are increasingly focusing on technologies related to “Furniture and Games”. EU15, South EU and Latin America maintain a Continuous Advantage in the “Other fields“ sector. North America, the former USSR and Middle East have lost Advantage in this sector.

Table 3: Shifting sectors of RTA (35 technologies) in patents in World Regions

↑ Continuous Advantage ↓ Continuous Disadvantage ↘ Lost Advantage ↗ New Advantage

Technological Area	Technology	Field Dynamics*	World Region							
			CEE	EU15	South EU	former USSR	Latin America	middle East	north America	Asia Pacific
Electrical engineering	Electrical machinery, apparatus, energy	-0,63	↓	↓	↓	↓	↓	↓	↓	↑
Electrical engineering	Audio-visual technology	0,03	↓	↓	↓	↓	↓	↓	↓	↑
Electrical engineering	Telecommunications	1,38	↓	↓	↓	↓	↓	↗	↗	↑
Electrical engineering	Digital communication	2,17	↓	↗	↓	↓	↓	↗	↗	↘
Electrical engineering	Basic communication processes	-1,00	↓	↓	↓	↘	↓	↗	↗	↘
Electrical engineering	Computer technology	2,66	↓	↓	↓	↓	↓	↗	↗	↘
Electrical engineering	IT methods for management	1,45	↓	↓	↓	↓	↓	↗	↗	↑
Electrical engineering	Semiconductors	1,07	↓	↓	↓	↓	↓	↓	↓	↑
Instruments	Optics	0,12	↓	↓	↓	↓	↓	↓	↓	↑
Instruments	Measurement	-2,04	↑	↗	↓	↑	↓	↓	↗	↓
Instruments	Analysis of biological materials	0,02	↑	↑	↗	↑	↗	↑	↘	↓
Instruments	Control	-0,19	↗	↗	↑	↘	↑	↑	↗	↘
Instruments	Medical technology	0,92	↗	↑	↑	↑	↑	↑	↑	↓
Chemicals	Organic fine chemistry	-0,47	↑	↑	↑	↗	↗	↘	↘	↓
Chemicals	Biotechnology	0,38	↑	↑	↑	↗	↑	↑	↘	↓
Chemicals	Pharmaceuticals	1,15	↑	↘	↑	↗	↗	↑	↘	↓
Chemicals	Macromolecular chemistry, polymers	-0,53	↑	↓	↓	↓	↓	↓	↘	↑
Chemicals	Food chemistry	0,75	↑	↓	↑	↗	↑	↑	↘	↓
Chemicals	Basic materials chemistry	-0,25	↑	↘	↓	↗	↑	↘	↘	↗
Chemicals	Materials, metallurgy	-1,61	↑	↓	↓	↑	↗	↓	↓	↗
Chemicals	Surface technology, coating	-0,42	↘	↓	↓	↓	↓	↓	↗	↑
Chemicals	Micro-structural and nano-technology	0,14	↗	↑	↘	↗	↑	↓	↘	↑
Chemicals	Chemical engineering	-1,01	↑	↑	↑	↑	↑	↘	↘	↓
Chemicals	Environmental technology	0,33	↑	↑	↗	↑	↗	↘	↘	↗
Mechanical engineering	Handling	-0,92	↑	↑	↑	↘	↑	↓	↘	↓
Mechanical engineering	Machine tools	-2,49	↑	↗	↗	↑	↓	↓	↓	↓
Mechanical engineering	Engines, pumps, turbines	-0,74	↗	↑	↑	↗	↑	↓	↓	↘
Mechanical engineering	Textile and paper machines	-0,87	↘	↓	↑	↓	↓	↓	↓	↑
Mechanical engineering	Other special machines	-1,27	↑	↑	↑	↑	↑	↑	↘	↓
Mechanical engineering	Thermal processes and apparatus	-0,68	↗	↘	↗	↑	↗	↘	↓	↑
Mechanical engineering	Mechanical elements	-0,31	↑	↑	↑	↑	↑	↘	↘	↓
Mechanical engineering	Transport	1,13	↗	↑	↑	↓	↑	↓	↘	↓
Other fields	Furniture, games	1,65	↗	↘	↑	↓	↑	↘	↑	↗
Other fields	Other consumer goods	0,53	↓	↑	↑	↓	↑	↑	↑	↓
Other fields	Civil engineering	-0,46	↑	↑	↑	↑	↑	↘	↘	↓

*See Table 1

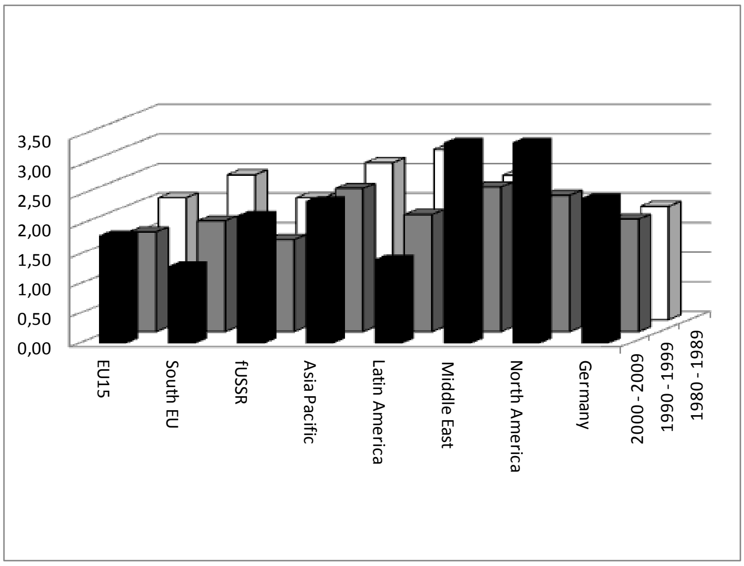
3.3 Convergence analysis by means of a Structural Deviation Indicator

To explore convergence and divergence trends among the technological specialization profiles of the world regions considered we use a structural deviation indicators (SDI) at the level of the technology (35 technologies). The formula is as follows:

$$SDI = \sqrt{\sum_k \left(sh\frac{x}{k} - sh\frac{y}{k}\right)\left(sh\frac{y}{k} / 100\right)} \text{ where}$$

x = CEE
y = compared region
k = technology
sh_k^x = share of patents according to technology k in CEE
sh_k^y = share of patents according to technology k in compared region

Figure 6: Structural deviation indicators between CEE and World regions considering 35 technologies[9]



Source: PATSTAT October 2012. Authors calculations

Figure 6 gives Structural Deviation Indicators (SDI) between different world regions and CEE. The lower the value of the indicators, the more similar are world regions considered to CEE. According to data available, the technological profile of CEE (35 technologies) converges clearly over time with the technological profiles of EU15 and South EU and Latin America (the indicator becomes lower) and diverges with the profiles of North America and the Middle East. The differences between the technological profiles of CEE and Asia Pacific and between CEE and the former USRR do not vary as pronouncedly as in the case of the other regions. Interestingly, after a

[9] Data available in Annex.

convergence in the transition period 1990-1999 a divergence can be observed between the technological profiles of the CEE and the former USSR in the most recent period.

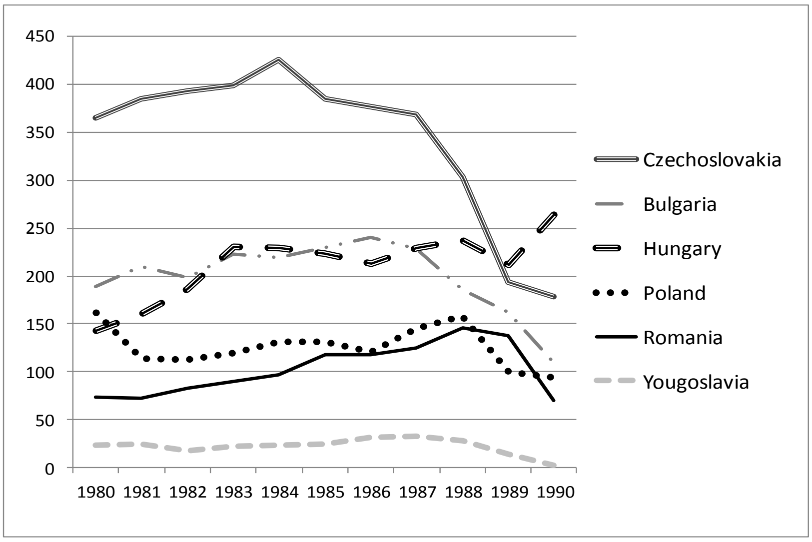
4. Patenting in CEE: national trends and technological profiles

4.1. General trends in CEE countries

This section focuses on the patenting activities of CEE economies in terms of priority patent applications. Figures 5 and 6 give the patent intensity of CEE countries in two different periods. As already pointed out in the comparison of CEE with other world regions, the indicators at the national level suggest (except for a few economies) a rather weak development in the technological activities of CEE economies in 2000-2009 compared with the period 1980-1989.

Figures 7 and 8 give the patent intensity of CEE countries in these two periods. In the first period 1980-1990 (see Figure 7) the countries maintain a relatively stable level of priority patents per capita until 1987-1988. Czechoslovakia was clearly the leader country in terms of patent intensity until 1988 followed by Bulgaria and Hungary. However, its strong decline in patent intensity started already in 1980s. Among the 6 countries given in figure 7, only Hungary has been able to maintain its patent intensity (and even slightly increase it) until 1990.

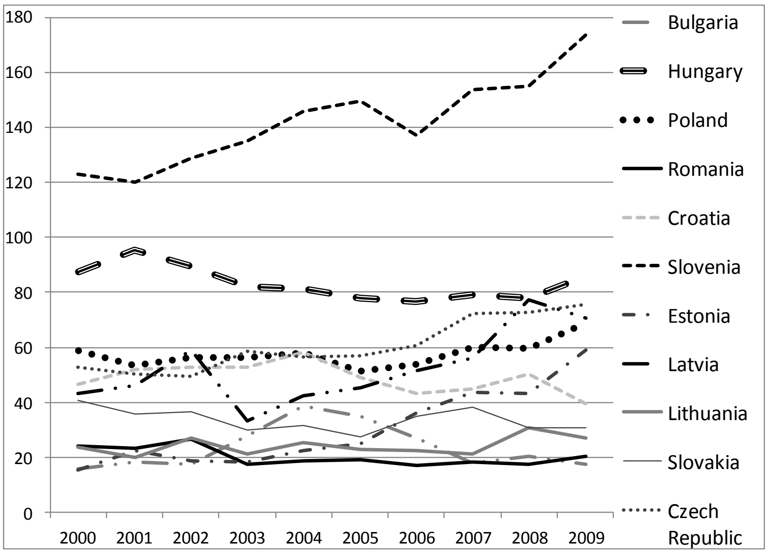
Figure 7: Patent intensity of CEE countries in the period 1980-1990



Source: PATSTAT October 2012. IWH Calculations

Figure 8 gives a quite different picture of the patenting activities in CEE in the period 2000-2009 in terms of national patent intensity. First, patent intensity of all CEECs has been dramatically reduced from the range between 70-250 (except ex-Yugoslavia) at the end of 1980s to a range in between 20-120 in first decade of 21st century. Second, after 1990 relatively small new countries contribute to the technological activities of the region. Among the traditional leaders of the period 1980-1990 in terms of patent intensity, only Hungary is able to maintain a leading position at half of its socialist patent intensity behind Slovenia which has become the economy with increasing levels of patent intensity and an almost constant positive growth rate throughout the latest period. The Czech Republic, Poland and especially Latvia increase their levels of patent intensity approaching Hungary`s level in 2008. Estonia shows strong growth between 2005 and 2009 as well. These four countries (Czech Republic, Poland, Latvia and Estonia) build a group of countries with increasing patent intensity after 2005 getting closer to the level of Hungary. Croatia, on the other hand, does not follow the pace of this group and reduces its patent intensity after 2004. Finally Lithuania, Slovakia, Bulgaria and Romania build the group of countries with the lowest patent intensity bellow 40 patents per million inhabitants.

Figure 8: Patent intensity of CEE countries in the period 2000-2009



Source: PATSTAT October 2012. IWH Calculations

Table 4 gives the cumulative patent intensity in three periods for the CEE economies and selected economies in the world for comparison10. The data suggest a slowdown of the technological activities in CEE countries in the period 2000-2009 except for Slovenia, Estonia, Poland and Slovakia. Slovenia holds by far the largest number of priority patent applications per capita and reaches the level of Denmark in the period

10 The cumulative patent intensity considers the patent output in each 10-years period in terms of the population in the last year of each period. We have excluded Japan from analysis due to strong institutional bias (patent propensity of the Japanese national innovation system).

2000-2009. Estonia experiences remarkable growth after 2005. Moreover, the data point out an increase of the patent activities in the benchmark countries except for Russia, Ukraine and the fUSSR[11.] The overall patent activity in the fUSSR has dropped at rate similar to CEECs. However, Russian patent activity has fully recovered and is at level well above CEECs and is above Denmark and Slovenia though still behind leading patenting countries.

The picture that emerges shows dramatic shifts among country groups in terms of catching up, falling behind and forging ahead. First, there is dramatic falling behind of the CEE in between socialist period (1980-89) and the last decade (2000-2009). In per capita terms cumulative patent intensity of CEE in socialist period was clearly behind UK and Germany but equal or higher than the US and several times higher than intensity of Korea and Taiwan. However, this picture has dramatically reversed during transition as Korea and Taiwan not only caught up but forged ahead in terms of patent intensity.

Second, during the post-socialist period patent intensity of the CEECs (except Slovenia) has fallen further behind. So, economic recovery and catch-up during the 2000-09 period has not been followed by increasing patent intensity. This corroborates well Kravtsova and Radosevic (2011) who show that increases of productivity in post-socialist countries are closely related to increases in production capability, not to technology intensity measured by resident patents.

11 Data for Denmark and Ireland are not reliable in the first two periods. Before 1993 Inventor location was not available in the documents published by the Irish Patent Office and complied in PATSTAT. For this reason the algorithm designed by de Rassenfosse et al.(2013)to assign a geographical location to inventions published by the Danish offices uses mainly the location of the Publication Authority (Denmark) rather than the location of the inventor to assign a geographic location the documents from this office. The Data for Denmark overestimates the technological activities being carried out in Denmark until 1993. The same happens for Ireland until 1989.

Tabel 3: Cumulative Patent Intensity (cumulative priority patent applications per 1 mio inhabitants per period) in CEE and benchmark countries (1980-1989, 1990-99, 2000-09)*

	1980-1989	1990-1999	2000-2009
Slovenia	n.a	815	1422
Hungary	1956	1266	833
Czech Republic	n.a	642	606
Poland	1304	655	576
Latvia	n.a.	573	524
Croatia	n.a.	269	489
Slovakia	n.a.	317	337
Estonia* (3)	n.a.	1479	305
Lithuania	n.a.	271	241
Bulgaria	1763	368	236
Romania	987	445	202
South Korea	375	5268	20169
Taiwan	175	1674	8802
Germany	3272	3631	4889
United Kingdom	2390	3056	3104
Israel	2215	2608	2758
USA	1339	1852	2259
Russia (1)	3810	1368	1603
Denmark**	n.a.	n.a.	1422
Ireland**	n.a.	n.a.	1013
fUSSR (2)	2322	818	921
China	18	77	691
Spain	396	398	573
Ukraine (1)**	1069	400	410
Portugal	90	99	209
Brazil	148	145	194
Turkey	10	13	70
Chile	5	6	27
India	8	9	9

Source: PATSTAT October 2012. IWH Calculations

*Per capita data based on last years' population in each period

** Coverage problems for Denmark (before 1993), Ireland (before 1989) and Ukraine (in 2003) reduce credibility of their data

(1) Data for the periods 1980-1989 and 1990-1999 have been estimated based on the total priority applications in the fUSSR region in the respective periods and the share of the country in the fUSSR priority patent output in the period 2000-2009

(2) fUSSR includes national data for the former USSR countries excluding the Baltic countries.

(3) Data for Estonia between 1990 and 1996 are above average reaching over 300 priority patents per Mio inhabitant in 1992 and 1993. After 1996 the patent intensity reduces drastically to 20 patents per Mio inhabitant.

4.2 Technological specialization in CEE countries

This section analyzes the specialization profiles of CEE countries based on the Revealed Technological Advantage (RTA) Indicator and on the shifts observed in the indicators across 5 technological sectors and 35 technologies over time. Again, the specialization analysis takes into consideration the technological dynamism of technological sectors and fields in order to assess whether countries are accumulating knowledge in technological fields with increasing technological opportunities at the technological frontier.

Table 5 gives a classification of technological sectors for CEE economies considering the patterns of specialization. “Chemicals” and “Mechanical Engineering” are traditional sectors of revealed technological advantage (Continuous Advantages). CEE economies show also a persistent revealed technological advantage in some instrument technologies (measurement and analysis of biological materials) and in civil engineering. Moreover, the data suggest that, together with the sector of “other fields”, the technologies where CEE is newly specializing (Newly Gained Advantages) are in the sectors of “Chemicals” and “Mechanical Engineering”, where CEE has traditionally had a strong specialization. Interestingly, the technology fields in these sectors where CEE is diversifying more recently and starting to accumulate knowledge belong to the most dynamic sectors (micro-structural and nano-technology in the chemicals sector and transport in the mechanical engineering sector). This development suggests that CEE economies have strengthened their focus on their traditional technological sectors being able also to diversify toward most dynamic technological fields. Moreover, CEE is focusing also in technological fields beyond their core sectors such as in “control”, and “medical technologies” (Instruments) or in “furniture and games” (Other fields). Again, “furniture and games” show a very dynamic trend in the technological landscape which confirms the ability of CEE to participate in selected technological activities with increasing technological opportunities. However, CEE maintains in all technology fields of “Electrical Engineering” showing increasing technological opportunities a continuous disadvantage over time.

Table 5: Shifting technologies of RTA in CEE (35 technological fields)

	RTA >1 (1980-89) (Traditional advantages)	**RTA <1 (1980-1989) (Traditional disadvantages)**
RTA >1 (2000-09) (new advantages)	Measurement (I), analysis of biological materials* (I), organic fine chemicals (C), biotechnology* (C), pharmaceuticals** (C), macromolecular chemicals and polymers (C), food chemicals* (C), basic materials chemicals (C), materials and metallurgy (C), chemical engineering (C), environmental technology* (C), handling (ME), machine tools (ME), other special machines (ME), mechanical elements (ME), civil engineering (O) **Fields of continuous advantages**	Control (I), medical technology *(I), micro-structural and nano-technology* (C), engines, pumps and turbines (ME), transport** (ME), furniture and games** (O), **Fields of newly gained advantages**
RTA <1 (2000-09) (new disadvantages)	surface technology and coating (C), textile and paper machines (ME) **Fields of lost advantages**	electrical machinery, apparatus and energy (EE), audio-visual technology* (EE), telecommunications** (EE), digital communication*** (EE), basic communication processes (EE), computer technology***(EE), IT methods for management** (EE), Semiconductors** (EE), Optics* (I), other consumer goods* (O) **Fields of continuous disadvantages**

*Indicator for technological dynamism >0
**Indicator for technological dynamism >1
*** Indicator for technological dynamism>2 (See Table 1)

Tables 6, 7 and 9 give information at the national level on changes in the specialization of countries in 5 technological sectors (Tables 6 and 7) and in 35 technology fields (Table 9). Technological sectors and technology fields are again classified as Continuous Advantages, Gained Advantages, Lost Advantages and Continuous Disadvantages. The technological dynamism of the sectors and fields is given in the tables according to technological dynamics indicator from table 1. Table 6 includes large CEE countries (Bulgaria, Hungary, Romania and Poland) and Table 7 includes smaller CEE countries (Croatia, CZ, EE, LT, LV, SK, SI).

Again the data confirms that Chemicals and Mechanical Engineering are clearly sectors of “Continuous Advantage” in CEE economies. The focus on Chemicals is persistent over time in all CEE countries. Organic fine chemicals, Basic Materials Chemistry, Chemical Engineering, Pharmaceuticals and Environmental Technology are the technologies in **Chemicals** where CEE countries have a “Continuous Advantage” (See Tables 6, 7 and 9). Interestingly, the fields “Pharmaceuticals” and “Environmental Technology” show a strong dynamic in the chemicals sector. However, “Micro-Structural and Nano-technologies” (which are also classified in the Sector of Chemicals) belong to the technologies of “Continuous Disadvantages” in 7 CEE countries.

Table 6. Shifting sectors of RTA (5 technological groups) in patents (BG, HU, RO, PL)

	RTA >1 (1980-89) (traditional advantages)	RTA <1 (1980-1989) (traditional disadvantages)
RTA >1 (2000-09) (new	***BG:*** chemicals ***HU:*** chemicals, other fields* ***PL:*** chemicals, other fields* ***RO:*** chemicals, mechanical eng. **Sectors of continuous advantages (7)**	***BG:*** mechanical eng. ***HU:*** mechanical eng. ***PL:*** mechanical eng. ***RO:*** other fields* **Newly gained advantages (4)**
RTA <1 (2000-09) (new disadvantages)	***BG:*** - ***HU:*** - ***PL:*** - ***RO:*** - **Sectors of lost advantages (0)**	***BG:*** electrical eng., instruments, other fields ***HU:*** electrical eng.*, instruments ***PL:*** electrical eng.*, instruments ***RO:*** electrical eng.*, instruments **Sectors of continuous disadvantages (9)**

*Indicator for technological dynamism >0 (See Table 1)

In what concerns **Mechanical Engineering**, the continuous revealed technological advantage is mainly driven by smaller countries together with Romania. Slovenia, Slovakia, and Croatia have increased their share of technological activities in this field notably in the period 2000-09 (see Table 9). Surprisingly larger countries (BG, HU, PL) do not hold a continuous advantage and have only specialized in mechanical engineering in the most recent period. Despite their late specialization, according to the absolute number of priority patent applications and the national shares in CEE given in Table 7, these countries hold the largest stake of technological activities in Mechanical Engineering in the CEE region. Within the sector of Mechanical Engineering, the technologies related to “Other special machines” are the technologies where most CEE economies hold a Continuous Advantage. In the technologies “Engines, Pumps, and Turbines” and in “Thermal Processes and Apparatus” specialization is either continuous or is increasing. All countries except for Romania, Estonia and Latvia show either a continuous or increasing advantage in the field “Transport”, which is the only field with a positive indicator of technological dynamism in the sector (See Table 9).

Table 7: Shifting sectors of RTA (5 technological groups) in patents (HR, CZ, EE, LT, LV, SK, SI)

	RTA >1 (1990-99) (traditional advantages)	RTA <1 (1990-1999) (traditional disadvantages)
RTA >1 (2000-09) (new advantages)	***CZ:*** chemicals, mechanical eng., other fields* ***EE:*** instruments, chemicals ***HR:*** chemicals, mechanical eng., other fields* ***LT:*** instruments, chemicals, other fields* ***LV:*** chemicals ***SK:*** chemicals, mechanical eng., other fields* ***SI:*** chemicals, mechanical eng., other fields* **FIelds of continuous advantages (18)**	***CZ: -*** ***EE: -*** ***HR: -*** ***LT:*** mechanical eng. ***LV:*** instruments, other fields* ***SK: -*** ***SI: -*** **Newly gained advantages (3)**
RTA <1 (2000-09) (new disadvantages)	***CZ: -*** ***EE:*** mechanical eng., other fields* ***HR: -*** ***LT: -*** ***LV: -*** ***SK: -*** ***SI: -*** **Fields of lost advantages (2)**	***CZ:*** electrical eng.*, instruments ***EE:*** electrical eng. * ***HR:*** electrical eng. *, instruments ***LT:*** electrical eng. * ***LV:*** electrical eng. *, mechanical eng. ***SK:*** electrical eng. *, instruments ***SI:*** electrical eng. *, instruments **Fields of continuous disadvantages (12)**

*Indicator for technological dynamism >0 (See Table 1)

The continuous Technological Disadvantage in the sector of **Instruments** persists in all countries except in Estonia and Lithuania which surprisingly display here a Continuous Technological Advantage in “Medical technology” and “Measurement” (see Table 9). Despite the relative low focus on the Sector of Instruments of CEE countries, two Instrument-technologies have strong weight in the national technological profiles (see Table 9): “Analysis of biological Materials” and “Medical technology”, which are complementary technologies to technologies in Chemicals and, moreover, show positive indicators of technological dynamism.

Electrical Engineering is also a continuous Technological Disadvantage in all CEE economies. The disregard of Semiconductors, Audio-visual technology, and Telecommunication technologies is persistent in all CEE countries considered. Estonia is the only country which has a newly gained advantage in two Electrical Engineering technologies (“Digital Communication” and “IT methods for management”). These fields experience strong growth of technological opportunities. The results suggest that Estonia has among the CEE countries the strongest ability to enter dynamic technological fields in the Electrical Engineering sector. In Hungary, Digital Communication is also a newly gained technological advantage. Finally, Latvia has recently specialized in "Basic Communication Processes". These are the few exceptions to the overall relative disregard of Electrical Engineering in CEE.

Finally, in the sector **"Other fields"** technologies for "Civil Engineering" display continuous Technological Advantage in all CEE countries except in Bulgaria and Romania, where specialization is not continuous but has increased in the most recent period. However, "civil engineering" does not belong to the dynamic technological fields in the period 2000-2009. Latvia experiences a Newly Gained Revealed Technology Advantage in technologies for "Furniture and Games", a field strong increase in technological opportunities.

Table 8: Priority Patent Applications in Mechanical Engineering in CEE countries. Total Number and National Shares

Mechanical Engineering			
Country	**1980-1989**	**1990-1999**	**2000-2009**
Bulgaria (BG)	30843(15,2%)	5194 (4,0%)	3542 (3,4%)
Hungary (HU)	40212(19,8%)	11893 (9,2%)	11368 (10,9%)
Poland (PL)	76178(37,4%)	51873 (39,9%)	45640 (43,9%)
Romania (RO)	56322(27,7%)	19698 (15,2%)	8887 (8,6%)
Czech Republic (CZ)	n.a.	19946 (15,4%)	16499 (15,9%)
Estonia (EE)	n.a	5071 (3,9%)	382 (0,4%)
Croatia (HR)	n.a	3593 (2,8%)	5229 (5,0%)
Lithuania (LT)	n.a	1522 (1,2%)	1371 (1,3%)
Latvia (LV)	n.a	2501 (1,9%)	651 (0,6%)
Slovenia (SI)	n.a	4470 (3,4%)	5739 (5,5%)
Slovakia (SK)	n.a	4168 (3,2%)	4624 (4,4%)
	205372(100%)	129929 (100%)	103931 (100%)

Table 9: Shifting areas of RTA (35 technologies) in patents in CEE countries

⇧ Continuous Advantage ⇩ Continuous Disadvantage ⇘ Lost Advantage ⇗ New Advantage

Technological Sector	Technology Field	Field Dynamics*	Country											Number of countries where technology experinces a			
			BG	HU	PL	RO	HR	CZ	EE	LT	LV	SK	SI	⇩	⇘	⇗	⇧
Chemicals	Organic fine chemicals	-0,47	⇘	⇧	⇧	⇧	⇧	⇧	⇧	⇧	⇧	⇧	⇧	0	1	0	10
Chemicals	Pharmaceuticals	1,15	⇧	⇧	⇗	⇧	⇧	⇧	⇧	⇧	⇧	⇧	⇧	0	0	1	10
Instruments	Analysis of biological materials	0,02	⇧	⇧	⇧	⇧	⇩	⇧	⇧	⇧	⇧	⇧	⇩	2	0	0	9
chemicals	Basic materials chemicals	-0,25	⇧	⇧	⇧	⇧	⇘	⇧	⇧	⇧	⇧	⇧	⇩	1	1	0	9
chemicals	Chemical engineering	-1,01	⇧	⇧	⇧	⇧	⇩	⇧	⇧	⇧	⇗	⇧	⇧	1	0	1	9
chemicals	Environmental technology	0,33	⇗	⇧	⇧	⇗	⇧	⇧	⇧	⇧	⇧	⇧	⇧	0	0	2	9
Mechanical engineering	Other special machines	-1,27	⇧	⇧	⇗	⇗	⇧	⇧	⇧	⇧	⇧	⇧	⇧	0	0	2	9
Other fields	Civil engineering	-0,46	⇗	⇧	⇧	⇗	⇧	⇧	⇧	⇧	⇧	⇧	⇧	0	0	2	9
chemicals	Biotechnology	0,38	⇧	⇧	⇧	⇘	⇘	⇧	⇗	⇧	⇧	⇧	⇧	0	2	1	8
chemicals	Materials, metallurgy	-1,61	⇧	⇩	⇧	⇧	⇩	⇧	⇧	⇧	⇧	⇧	⇩	3	0	0	8
Instruments	Medical technology	0,92	⇧	⇧	⇗	⇗	⇧	⇧	⇧	⇧	⇧	⇩	⇘	1	1	2	7
chemicals	Food chemicals	0,75	⇧	⇧	⇧	⇘	⇗	⇧	⇘	⇧	⇧	⇧	⇘	0	3	1	7
Mechanical engineering	Engines, pumps, turbines	-0,74	⇗	⇗	⇗	⇗	⇧	⇧	⇧	⇧	⇧	⇧	⇩	1	0	4	6
Instruments	Measurement	-2,04	⇧	⇘	⇧	⇧	⇩	⇗	⇧	⇧	⇘	⇘	⇗	1	3	2	5
Mechanical engineering	Thermal processes and apparatus	-0,68	⇗	⇧	⇗	⇗	⇧	⇧	⇗	⇧	⇘	⇗	⇧	0	1	5	5
Mechanical engineering	Mechanical elements	-0,31	⇩	⇘	⇧	⇧	⇘	⇧	⇩	⇩	⇩	⇧	⇧	4	2	0	5
chemicals	Macromolecular chemicals, polymers	-0,53	⇘	⇩	⇧	⇧	⇩	⇩	⇧	⇩	⇩	⇧	⇩	6	1	0	4
Mechanical engineering	Machine tools	-2,49	⇘	⇩	⇧	⇧	⇗	⇧	⇘	⇩	⇘	⇩	⇧	3	3	1	4
Mechanical engineering	Transport	1,13	⇗	⇗	⇗	⇩	⇧	⇧	⇘	⇩	⇩	⇧	⇧	3	1	3	4
Other fields	Furniture, games	1,65	⇩	⇧	⇩	⇩	⇧	⇩	⇩	⇩	⇗	⇧	⇧	6	0	1	4
Instruments	Control	-0,19	⇩	⇧	⇩	⇩	⇧	⇗	⇗	⇩	⇗	⇩	⇗	5	0	4	2
Mechanical engineering	Handling	-0,92	⇗	⇩	⇧	⇩	⇗	⇩	⇗	⇗	⇩	⇩	⇧	5	0	4	2
Other fields	Other consumer goods	0,53	⇩	⇩	⇩	⇩	⇧	⇩	⇩	⇗	⇩	⇩	⇧	8	0	1	2
Electrical engineering	Electrical machinery, apparatus, energy	-0,63	⇩	⇩	⇩	⇗	⇩	⇩	⇩	⇩	⇘	⇩	⇧	8	1	1	1
chemicals	Surface technology, coating	-0,42	⇘	⇩	⇘	⇗	⇩	⇩	⇩	⇧	⇩	⇩	⇩	7	2	1	1
Mechanical engineering	Textile and paper machines	-0,87	⇩	⇩	⇩	⇘	⇩	⇧	⇩	⇩	⇩	⇩	⇩	9	1	0	1
Electrical engineering	Audio-visual technology	0,03	⇩	⇩	⇩	⇩	⇩	⇩	⇩	⇩	⇩	⇩	⇩	11	0	0	0
Electrical engineering	Telecommunications	1,38	⇩	⇩	⇩	⇩	⇩	⇩	⇩	⇩	⇩	⇩	⇩	11	0	0	0
Electrical engineering	Digital communication	2,17	⇩	⇗	⇩	⇩	⇩	⇩	⇗	⇩	⇩	⇩	⇩	9	0	2	0
Electrical engineering	Basic communication processes	-1,00	⇩	⇩	⇘	⇩	⇩	⇩	⇩	⇩	⇗	⇘	⇩	8	2	1	0
Electrical engineering	Computer technology	2,66	⇗	⇩	⇩	⇩	⇩	⇩	⇩	⇩	⇩	⇩	⇩	10	0	1	0
Electrical engineering	IT methods for management	1,45	⇩	⇩	⇩	⇩	⇩	⇩	⇗	⇩	⇩	⇩	⇩	10	0	1	0
Electrical engineering	Semiconductors	1,07	⇩	⇩	⇩	⇩	⇩	⇩	⇩	⇩	⇩	⇩	⇩	11	0	0	0
Instruments	Optics	0,12	⇩	⇩	⇩	⇩	⇩	⇩	⇩	⇩	⇩	⇩	⇩	11	0	0	0
chemicals	Micro-structural and nano-technology	0,14	⇗	⇩	⇩	⇩	⇩	⇗	⇩	⇩	⇗	⇩	⇗	7	0	4	0

*See Table 1

5. Main findings

General Trends

- CEE seems to have reduced its patenting activities drastically in absolute and per capita terms after 1990 and maintains now a stable level below the performance of EU15 and South EU and the former USSR.
- Asia Pacific is in absolute terms the strongest region in the number of priority patents even if we eliminate Japan. In the 1990s, China and Korea have increased their technological activities notably.
- EU15 is the second strongest world region followed quite closely by North America in terms of absolute number of priority patents. EU15 seems to be able to maintain the level of patent applications after 2005 while North America's annual level decreases slightly.
- The former USSR experiences a strong decrease in the number of priority patent applications after 1990 and recovers only slightly at the end of 1990s. However, their level stays above the CEE.
- Asia Pacific and North America are the regions with the largest share of high technology patents in its total priority patents output (20% in 2009).
- In CEE the share of high-technology patents started to increase from 2.5% in 1997 to reach about 7% in 2008 outperforming South EU. In 2009 the CEE share declines and remains below the EU15 share of 9%.

Technological specialization of World Regions

- The consideration of the RTA indicators in two time periods 1980-1989 and 200-2009 suggests a strong persistency in the technological specialization of regions since 1980. A weak shift in the specialization profile can be observed in certain regions towards Chemicals (former USSR and Latin America) and towards Electrical Engineering (North America and Middle East). Asia Pacific continue to specialize very strongly in electrical engineering and has disadvantages in all other sectors.
- "Chemicals" and "Mechanical Engineering" are traditional sectors of technological specialization in Europe and Latin America while "Electrical Engineering" and "Instruments" are sectors of strong specialization in Asia Pacific, North America and Middle East.
- A Continuous Advantage in "Electrical Engineering" is clear in Asia Pacific. The specialization indicators for this region (RTA) are recently very strongly and narrowly confined on "Telecommunication", "Audio visual Technologies" and "Electrical machinery, apparatuses and Energy".

- The results suggest a division of labor in technological activities among world regions where Europe, Latin America and the former USSR are mainly specializing in sectors losing technological dynamism in the global patent activities (Chemicals and/or Mechanical Engineering). While North America, the Middle East (especially Israel) and Asia Pacific are increasingly specializing in “Electrical Engineering”, the sector with strong technological opportunities. These regions are hence broadening their technological capabilities in the more dynamic technological fields at the technological frontier.
- The technological profile of CEE converges clearly over time with the technological profiles of EU15 and South EU and diverges with the profiles of North America and the Middle East.
- A slight divergence can be observed between the technological profiles of the CEE and the former USSR and a slight convergence between the profiles of CEE and Asia Pacific.

CEE Economies

- A slowdown of the technological activities in CEE countries in the period 2000-2009 except for Slovenia, Croatia and Slovakia. Economic recovery and catch-up during the 2000-09 period has not been followed by increasing patent intensity.
- Slovenia holds by far the largest number of priority patent applications per capita and reaches the level of Denmark in the period 2000-2009.
- In the 2000-09 period patent intensity in Russia and Ukraine is above Slovenia, the highest ranked CEE country. This suggests that internal technology activity in Russia is still very much alive though it is not reflected in technological sophistication of Russian export. Chemicals and Mechanical Engineering, the sectors losing technological opportunities, are clearly sectors of specialization in CEE economies. Electrical Engineering and Instruments are the sectors of “Continuous Disadvantage”.
- The focus on Chemicals is persistent over time in all CEE countries. Organic fine chemicals, Pharmaceuticals, Basic Materials Chemistry, Chemical Engineering and Environmental Technology are the technologies in Chemicals where CEE countries have a “Continuous Advantage”. Except for Pharmaceuticals, these fields are losing dynamism in the technological landscape. However, CEE countries have gained specialization in dynamic chemical fields such as “Biotechnology” and “Environmental Technology”. This diversification towards chemical fields with technological dynamism suggests the ability of these countries to accumulate knowledge in the most dynamic chemical fields at the technological frontier and not only in the stagnant technology fields.

- A Continuous Technological Advantage in Mechanical Engineering is present in smaller CEE countries (Croatia, Slovenia, Slovakia and Czech Republic) together with Romania. Larger countries (BG, HU, PL) do not maintain a continuous advantage and have only specialized in mechanical engineering in the most recent period though at low absolute levels when compared to the first period. Poland, Hungary and Czech R hold the largest absolute numbers of patents in mechanical engineering as well as have the largest shares in the region. These results are quite discouraging if we consider that Mechanical Engineering is losing technological dynamism at the technological frontier.
- All countries except for Romania, Estonia and Latvia show either a continuous or increasing advantage in the field "Transport", which is the only field with a positive indicator of technological dynamism in the sector Mechanical Engineering.
- The weak specialization in Semiconductors, Audio-visual technology, and Telecommunication technologies is persistent in all CEE countries considered.
  Estonia is the only country which has a newly gained advantage in two dynamic Electrical Engineering technologies ("Digital Communication" and "IT methods for management"). The results suggest that Estonia has among the CEE countries the strongest ability to enter dynamic technological fields in the Electrical Engineering sector. In Hungary "Digital Communication" is also a newly gained technological advantage. Latvia has recently specialized in "Basic Communication Processes". Estonia, Hungary and Latvia are hence the CEE economies increasingly specializing in selected Electrical Engineering technology fields.

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7. Annex

Tabel A.1 Definition of world regions

CEE	Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia, Slovenia + Czechoslavakia and Yugoslavia
EU27	EU15 + CEE (excluding Croatia, Czechoslavakia and Yugoslavia)+ Malta and Cyprus
EU15	Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, UK
South EU	Cyprus, Greece, Italy, Malta, Spain, Portugal
Former USSR (exc. EU members)	Armenia, Azerbaijan, Belarus, Kazakhstan, Kyrgyzstan, Moldova, Russia, Tajikistan, Turkmenistan, Ukraine, Uzbekistan
North America	Canada, USA
Latin America	Argentina, Bahamas, Barbados, Belize, Bolivia, Brazil, Chile, Columbia, Costa Rica, Cuba, Dominican Republic, Equador, El Salvador, French Guiana, Grenada, Guadeloupe, Guatemala, Guyana, Haiti, Honduras, Jamaica, Martinique, Mexico, Nicaragua, Panama, Paraguay, Peru, Surinam, Trinidad & Tobago, Uruguay, Venezuela.
Asia Pacific	Australia, Bangladesh, Brunei, China, Hong Kong, India, Indonesia, Japan, Laos, Macau, Malaysia, Micronesia, Mongolia, Myanmar, Nepal, New Zealand, Pakistan, Philippines, Singapore, South Korea, Sri Lanka, Taiwan, Thailand, Vietnam
Middle East	Bahrain, Egypt, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Syria, Turkey, United Arab Emirates, Yemen

Tabel A.2 Structural deviation indicators

		Electrical Engineering	Instruments	Chemistry	Mechanical Engineering	Other fields	total
CEE/EU15	1980 - 1989	0,20	0,99	1,14	1,28	0,55	2,06
	1990 - 1999	0,30	0,34	1,24	0,85	0,61	1,68
	2000 - 2009	0,47	0,13	0,85	1,10	1,07	1,82
CEE/South EU	1980 - 1989	0,46	1,60	1,14	1,32	0,41	2,45
	1990 - 1999	0,17	0,76	1,20	0,93	0,76	1,87
	2000 - 2009	0,29	0,55	0,70	0,67	0,60	1,30
CEE/Former USSR	1980 - 1989	0,33	1,02	1,43	0,78	0,67	2,06
	1990 - 1999	0,15	0,82	1,09	0,67	0,31	1,55
	2000 - 2009	0,48	1,09	1,39	0,67	0,92	2,16
CEE/Asia Pacific	1980 - 1989	1,17	1,11	1,41	1,34	0,80	2,65
	1990 - 1999	1,04	0,69	1,51	0,73	1,21	2,42
	2000 - 2009	1,15	0,71	0,88	0,79	1,60	2,41
CEE/Latin America	1980 - 1989	0,30	1,52	1,43	1,55	1,20	2,87
	1990 - 1999	0,21	0,92	1,15	0,94	0,90	1,98
	2000 - 2009	0,26	0,71	0,62	0,71	0,75	1,42
CEE/Middle East	1980 - 1989	0,76	0,95	1,14	1,72	0,50	2,44
	1990 - 1999	0,84	1,12	1,38	0,89	1,14	2,44
	2000 - 2009	2,39	0,93	0,95	1,11	1,67	3,39
CEE/North America	1980 - 1989	0,33	0,85	1,07	1,25	0,44	1,93
	1990 - 1999	0,75	0,62	1,45	0,65	1,35	2,30
	2000 - 2009	2,41	0,46	1,20	0,95	1,78	3,39
CEE/Germany	1980 - 1989	0,26	0,87	1,13	1,20	0,33	1,92
	1990 - 1999	0,40	0,15	1,21	1,09	0,88	1,90
	2000 - 2009	0,46	0,17	0,90	1,64	1,51	2,46