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Assessing the Basis for 'Catching-Up' of Eastern Europe: an Analysis Based on US Foreign Patenting Data

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The main source of the US patent data between 1969-1994 used in this analysis is the SPRU Megatech data base. Megatech is the software package developed within the Microsoft Access which uses the US Patent Office data arranged from CASIS - Bibliographic CD-ROM. The US PTO data are transformed in accordance with the SPRU classifications of patents based on 34/99 technological groups and subgroups. Data for 1995-1996 are accessed from the US Patent Office database via Internet. Source of data from 1924-1969 is US Department of Commerce (1977).

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Summary

In this paper we explore the potential for technological catching-up by eastern Europe based on foreign US patents data. We analyse patent dynamics, sectoral specialisation and the institutional basis of eastern European US patenting since 1924 and particularly in the period 1969-1996. Our main conclusions are that, i) the levels and dynamics of US patenting of eastern Europe as a region are determined more by their income levels and growth rates than by specific features of the socialist economic system, ii) the technological advantages of eastern European economies are firmly rooted in their past successes and are very much based in metallurgical and mechanical technologies, and in chemicals/drugs with absolute and relative advantages in electronics being marginal, iii) there are significant intra-regional differences in the institutional basis of US foreign patenting which broadly follow inter-country differences in the institutional structure of R&D. Analysis indicates that the possibilities for patterns which would recombine world frontier R&D, design and manufacturing capabilities are not likely to occur across broad sectors, or the whole industry, but seem probable in the specific sectors in which these countries still have world frontier patentable inventions.

1 INTRODUCTION

Catching up by Eastern Europe (EE) with the EU economies requires high rates of growth sustained over a long period. Assuming a very optimistic 5% growth differential the number of years required after 1994 for convergence to the EU average ranges from 16 for Slovenia and Czech R to 35 and 37 for Bulgaria and Romania, respectively (Knell, 1996, p6). Such rates of growth require significant structural change which is possible only through intensive technological modernisation.

The scope for catching-up is determined both by the capabilities inherited from the socialist period as well as by the rate of technology mastery in the post-socialist period. The cumulative, path-dependent and local nature of technical change means that much future innovative activity in EE will originate from inherited technological capabilities. However, EE economies were closed economies where technology effort was mostly of an imitative ('reinventing the wheel') type which may not be directly relevant for sustainable growth over a longer period in a market economy context. In order to catch-up technologically EE economies will have to generate innovations which are relevant for the world market. The motivation for this paper is to analyse what is the basis for such a process.

In the 'classical' model of technology catching-up, learning is most intensive in the manufacturing phase and only subsequently do companies move into the design stage, involving R&D. A pattern of catching up involving the first tier Asian Newly Industrialised Economies (NIEs), analysed by Hobday (1995), describes basically this pattern. Its core is the inverse life cycle model where only in later stages have these economies developed innovative capabilities based on organised R&D. This path is particularly visible in the case of Korea and Taiwan where the dramatic rise in US foreign patenting has occurred only, since the mid-1980s (Choung, 1995).

The emerging experience of ex-centrally planned economies (CPEs), particularly of China, indicates the possibility of an alternative pattern of technology catching-up where the mastery of manufacturing capability is in parallel with, not subsequent to the deployment of design capabilities inherited from CPE period (see Gu Shulin and Steinmueller, 1996). This pattern - described in the example of Chinese electronics as the innovative recombination of technological capability - is possible due to design capabilities inherited from the period of closed economy and autarchic development.

While the first pattern may be summarised as a path from manufacturing to design and R&D, the second can be described as a shift from manufacturing/design/R&D to manufacturing/ design/R&D.

The motivation for this analysis is to explore what is the likely pattern of technology catching-up of eastern Europe. Will eastern Europe follow the emerging Chinese pattern in electronics, or the pattern of east Asian NIEs, whose growth was based on OEM (original equipment manufacturer) based on foreign design, or will it be an entirely new pattern, possibly based on combination of these two?

1.1 Use of US patent indicators in analysis of eastern European technological capabilities: possible biases

In order to explore this issue we are using the US foreign patenting data.[1] The advantages in using patents lie in a long and consistent time series, broad coverage and disaggregated data (OECD, 1994). Patents as indicators have several sources of bias: industry, country and firm specific (Pavitt, 1985). By this we mean that patents may not always reflect the true innovative potential in the economy and in specific sectors. However, the literature on patents points to a strong, almost proportional, link between R&D and patents especially for

[1]In the case of eastern European economies the US patent market is not the most important. It is the German patent market and recently the European patent system. However, the US patents posses a few advantages for our type of analysis. Accessibility of the data at disaggregated level as well as comparison with other comparable countries in much longer time period are much better in the case of the US patents.

firms above a minimum size (Grilliches, 1990). This means that these biases are applicable to R&D data as well. However, they are primarily applicable to domestic patenting. Foreign patenting does not introduce an additional bias (Soete and Wyatt, 1983). By foreign patenting bias we mean whether the number of domestic quality patents is reflected in foreign patenting.

There is a strong link between foreign patent grants and domestic R&D investments as well as between foreign patents and export (Soete, 1987). While there is industry bias to patent due to differences in technologies there is no additional industry specific bias with respect to industry's propensity to patent abroad.

Also, firm-specific biases in patenting are less evident in foreign patenting. Country specific biases in patenting are related to economic costs and benefits associated with patent protection, reflecting differences in patent legislation (Soete, 1987). For example, Japan has a high patenting bias across all industries. However, there are no additional country specific biases in foreign patenting. This is confirmed by a close inter-industry correlation between foreign and domestic patenting.

These ramifications are fully applicable to EE countries as market economies in the post-socialist period. However, our analysis stretches back into the period when EE economies were centrally-planned and when specific country biases in using the US patenting might have been quite pronounced. EE economies were closed economies in which incentives to protect innovation were weak. Whether this presumably low patenting bias was coupled with a foreign patenting bias is difficult to discover empirically.

The extent to which any country might be economically linked to a third country patent market, through international trade and/or foreign investments, could be an important factor in explaining the number of foreign patents obtained by such a country in some industries (Soete, 1987). But as emphasised by Soete (1987) there is no simple relation which checks

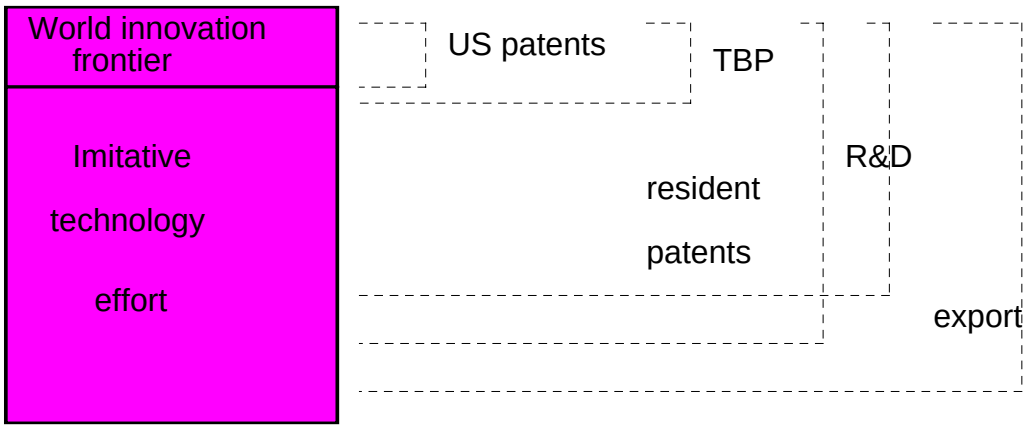
for the direction of the causality between two related, but distinct variables like foreign patenting and international trade. In the case of US patenting of eastern Europe in socialist period this link is not as straightforward as it may seem in the case of market economies.

In the case of market economies patenting is usually closely linked to exporting. However in the socialist period enterprises were not agents of patenting or direct exporters and the motivation for patenting was not directly linked to export considerations, or at least not to the export of products. Motivations related to direct export of technological knowledge or protection to avoid imitation by competitors on world market, irrespective of export, may seem to be more important. As we will outline later on, in ex-Soviet Union (ex-SU) foreign patenting was given high importance (OECD, 1969). This could mean that the foreign patenting bias may have been higher than expected. Irrespective of this, we show later on that US patents of EE economies broadly conform to their income levels and are not outliers. This may mean that despite their closed character the motivation for protection of technological knowledge abroad or its direct commercialisation abroad in these systems was much more pronounced than expected. Based on this, we take patent data at its face value with additional explanations regarding the institutional basis of foreign patenting.

1.2 US patents and catching up: what is measured?

US patent data are most commonly used in the case of developed OECD economies, most of which are at the innovation frontier. The relevance of the US foreign patenting is much less clear in the case of less developed or latecomer economies. A problem as to the relevance of the US patents arises not because of their possible bias as indicators but due to the fact that the technology effort of these economies is mostly not at the world innovation frontier. This results in relatively small numbers for these economies and creates the danger of over-interpreting small differences in patent numbers, especially over time. Figure 1 below depicts a framework for interpreting the US foreign patent data for latecomers.

Figure 1: Analytical framework for interpreting US foreign patent data for latecomers



Note: TBP=technological balance of payments

The technology effort in latecomer economies may be analytically divided into two components: innovative and imitative learning. Catching up is a function, among others factors, of both imitative and innovative learning. Imitative learning is learning behind the world frontier; innovative learning is technology development at the world innovation frontier. The US foreign patents measure primarily commercially relevant technological effort at the world frontier. As depicted above other indicators capture much better the majority of technological effort in latecomer economies which is imitative or behind the world frontier. The US patents for these economies measure only a minor part of the overall technological effort, that which is at the world innovation frontier. This means that the interpretation of US patent data for these economies should be different. Because the link between US foreign patenting and the growth of the latecomer economy may either not be strong or completely absent in the early phases of catching up. The cases in point are Korea and Taiwan whose economies had been growing vigorously for some time whereas in terms of US foreign patents visible increase is present only from the mid-1980s onwards (Choung, 1995). Latecomer economies may grow over long periods based on imitative learning or improvements in production and organisation which are not of patentable character. However, eventually long-term growth requires developed innovation capabilities which then become visible in US patenting accompanied by a higher technological content of export. This is especially relevant in the case of ex-centrally planned economies (CPEs) where much

of the technology effort was of the 'reinventing the wheel' type either because of autarchic conception of development or foreign restrictions on importing high-tech (CO-COM).

Thus, in the case of ex-CPEs the amount of imitative technological effort should have been significantly higher than in comparable medium income economies. This is confirmed by higher GERD/GDP ratios in socialist period. These are now falling to lower levels although they are still high in terms of, both R&D personnel and relative expenditures, when compared to similar income level countries (Auriol and Radosevic, 1996). However, higher imitative effort does not necessarily mean that the world frontier innovation output will be lower. In fact, it is possible to argue the opposite: higher imitative effort may create, as a spillover, a higher number of US patents. In other words, innovative effort may be considered as a proportional function of imitative effort, and not be inversely proportional.

In conclusion, US patents capture only part of the technology effort in latecomer economies. Irrespective of their size they indicate the existence of technology effort at the world innovation frontier. Like the tip of the iceberg they indicate the existence of underlying, much greater imitative technology effort or R&D behind the world frontier. Both angles of technology effort, imitative and innovative, are important in a long-term for catching up.

After these cautionary remarks regarding the interpretation of the US patenting data we want to emphasise the following three questions that drive our analysis.

First, what is the relative stock and dynamics of internationally commercially relevant S&T effort of EE economies, as represented by US patent data, when compared to other medium-income economies?

Second, what are the areas of inherited technological competencies in the post-socialist period and are past technological specialisations of EE related to regions catching up on the problems of today?

Third, what is the inherited institutional basis of US patenting, how is it changing in the post-socialist period, and how will it affect the prospects of individual EE countries for technology catching-up?

These questions are dealt with in the three following sections. In section 2, we analyse EE US patenting in relation to comparable medium income economies. In section 3 we look at the sectoral structure of US patenting at 34 and 99 patent classes. In section 4 we analyse institutional basis and changes in institutions that generate US patents in EE. In conclusion we summarise the main findings and interpret the results in a discussion of likely patterns of catching up of EE.

2 INTERNATIONAL COMPARISONS OF PATENT STOCKS AND DYNAMICS

In absolute terms, EE countries are not big patentors on the US market. Their levels of cumulative patents are far below those of the leading nine countries (Germany, France, UK, Netherlands, Japan, Italy, Switzerland, Sweden, Canada), whose shares are above 10%. The share of EE range from 3.8% (Former Soviet Union, further ex-SU) to 0.2% (Romania). However, EE countries have a strong presence among the group of small patentors (Table 1).

When comparing US foreign patents per 1m population in the period 1969-1994 the relative position of EE countries lies between the most developed OECD economies and the less developed medium-income economies (Figure 2).

Per capita in EE, US patents range from 200 (Hungary) to 12 (ex-Yugoslavia) which is above Mexico (13) and Brazil (5), which are considered here to be examples of less-developed economies. Per capita patenting of EE countries is similar to less developed EU economies whose GDP per capita are above the levels of EE countries. In less developed EU countries patents per capita range from 216 (Ireland) to 12 (Portugal). The only medium income

Table 1 Number of US foreign patents, 1969-1996, and their share in Germany =100

			%				%
1	Japan	330235	186.0	17	Denmark	4889	2.8
2	Germany	177587	100.0	18	Spain	2821	1.6
3	United Kingdom	70588	39.7	19	Norway	2796	1.6
4	France	67990	38.3	**20**	**Hungary**	**2173**	**1.2**
5	Canada	40972	23.1	**21**	**Form Czechoslovakia**	**1751**	**1.0**
6	Switzerland	35917	20.2	22	Mexico	1263	0.7
7	Italy	25866	14.6	23	New Zealand	1098	0.6
8	Sweden	22064	12.4	24	Ireland	1002	0.6
9	Netherlands	21823	12.3	25	Brazil	886	0.5
10	Taiwan	11162	6.3	**26**	**Poland**	**611**	**0.3**
11	Australia	8986	5.1	27	India	540	0.3
12	Belgium	8505	4.8	**28**	**Bulgaria**	**461**	**0.3**
13	Austria	8381	4.7	**29**	**Form Yugoslavia**	**341**	**0.2**
14	**Form Soviet Union**	**6681**	**3.8**	**30**	**Romania**	**323**	**0.2**
15	South Korea	6183	3.5	31	Greece	274	0.2
16	Finland	5229	2.9	32	Portugal	122	0.1

economies whose relative cumulative patenting is similar or above that of EE countries are Taiwan (359) and Korea (78), countries which are exemplars of catching-up. This indicates that, in per capita terms, EE patenting is not lower than would be expected from their income level. Figure 3, which plots GNP pc 1994 levels with US patents 1969-94, shows that EE economies are not in any respect outliers. Differences in correlation coefficients in regressions with and without EE countries are marginal. R^2 with EE countries changes from *0.629* to *0.621*.

Although technology is cumulative, examining patenting from 1969-1996 covers a long period during which much technology will have become obsolete and where changes in patent dynamics may be quite substantial. In Tables 2 and 3 patenting is broken down into three periods.

FIGURE 2: US FOREIGN PATENTS 1969-94 PER 1M POPULATION (1994)

FIGURE 3: GNPpc (1994) Vs USPAT per 1MN POP

Table 2: USPAT per 1 million pop (pop by the end of the periods)

1970 - 79 = 100

Country	1970-79	1980-89	1990-96/n	1980-89 %	1990-96/n %
Switzerland	2069	1846	1935	89	94
Sweden	978	930	873	95	89
Germany	713	845	892	118	125
United Kingdom	514	429	341	83	66
Canada	510	500	723	98	142
Netherlands	469	508	662	108	141
Japan	465	995	1735	214	373
France	401	421	517	105	129
Austria	343	401	455	117	133
Denmark	305	317	427	104	140
Belgium	285	263	406	92	142
Norway	218	223	297	102	136
Finland	186	366	696	197	375
Australia	152	202	259	133	170
Italy	129	162	218	126	169
Form Czechoslovakia	**69**	**27**	**14**	39	20
Ireland	56	88	196	158	352
Hungary	**53**	**104**	**67**	197	126
Spain	22	22	41	100	191
Bulgaria	**21**	**24**	**10**	118	46
Form Soviet Union	**14**	**8**	**3**	60	22
Greece	11	7	12	67	111
Romania	**11**	**2**	**1**	19	11
Taiwan	10	123	595	1219	5879
Poland	**8**	**5**	**4**	64	45
Mexico	7	5	5	66	67
Portugal	4	4	4	102	100
Form Yugoslavia	**3**	**5**	**9**	156	268
South Korea	2	12	180	686	10066
Brazil	2	2	4	119	239
Russia			5		

Table 3: USPAT per 1 million pop (pop by the end of the periods)

90-96 = 100

Country	1970-79	1980-89	1990-96/n.	70-79 %	80-89 %
Taiwan	10	123	595	2	21
Ireland	56	88	196	28	45
South Korea	2	12	180	1	7
Hungary	**53**	**104**	**67**	79	156
Spain	22	22	41	52	52
Form Czechoslovakia	**69**	**27**	**14**	499	194
Greece	11	7	12	90	61
Bulgaria	**21**	**24**	**10**	215	253
Form Yugoslavia	**3**	**5**	**9**	37	58
Mexico	7	5	5	149	97
Portugal	4	4	4	100	103
Brazil	2	2	4	42	50
Poland	**8**	**5**	**4**	220	141
Form Soviet Union	**14**	**8**	**3**	453	270
Romania	**11**	**2**	**1**	895	170

In the 1970-79 period the EE economies ranked relatively high when compared to less developed EU and other economies comparable in terms of income. Per capita US patents of all the less developed EU economies were either at *par* or below EE per capita patents. Per capita patents in Taiwan and Korea were below the EE average. Over the next ten years to 1989, there was a strong differentiation in per capita patenting among EE countries. While Hungarian, ex-Yugoslav and Bulgarian patents continued to rise in per capita terms by 197%, 156% and 118% respectively, per capita patenting of ex-Czechoslovakia, ex-SU, Poland and Romania deteriorated sharply to 39%, 60%, 64% and 19% respectively when compared to the 1970-79 level. This deterioration continued after 1989 in all EE countries, except, again Hungary and ex-Yugoslavia where US per capita patents rose by 126% and 268% respectively when compared to the 1970s. In all other EE economies per capita US patents had further decreased ranging from 46% (Bulgaria) to 11% (Romania) of their 1970s level. As a result of this change, EE countries in the 1990-96 period are not as distinctively different as they were in 1970s. Taiwan, Korea, and Ireland are now clearly far ahead of the EE top

per capita patentors while per capita patenting of Poland, ex-SU and Romania is on a par with or even behind relative levels of Mexico and Brazil. These figures point to a strong falling behind phenomenon in eastern Europe.

From a long-term perspective, there are two periods of catching-up by eastern Europe followed by periods of falling behind. By catching up or falling behind we identify those periods where US patenting was growing faster or slower in relation to the world US patenting (excluding the US) (see Figure 4).

The first period of catching up occurred with the break up of the Austro-Hungarian empire followed by the rise of US patenting from 1920-1931. In the period after 1931, until the beginning of the Second WW EE patenting was mainly following world patenting dynamics. The second period of catching-up started in 1955 and had exhausted itself by the beginning of the 1970s. From then until the present there was a period of falling behind world dynamics. When compared to less developed EU countries (Spain, Ireland, Portugal, Greece) EE countries record very similar dynamics of US patenting until the mid-1960s. From the mid-1960s to the early and mid-1970s EE patenting grew significantly faster than patenting by less developed EU economies. However, from the end of the 1970s, EU patenting continue to rise while EE patenting decrease consistently in absolute terms (see Figure 5).

The extent of EE falling behind is most obvious when compared with Austria, a neighbour of Hungary and ex-Czechoslovakia. In the period 1920 to 1928 the rate of growth of Austrian US patenting was similar to that of ex-Czechoslovakia. In the post-WWII period not only rates but also absolute levels were similar and this was the case until the early 1970s. From that time on, the gap widened not only in absolute but also in relative terms (Figure 6).

FIGURE 4: WORLD US FOREIGN PATENTING VS EASTERN EUROPEAN US FOREIGN PATENTING, 1920-1994

FIGURE 5: US FOREIGN PATENTING IN SELECTED COUNTRIES AND REGIONS

FIGURE 6: US FOREIGN PATENTING OF AUSTRIA, CZECHOSLOVAKIA AND HUNGARY

Falling behind by EE becomes sharply visible when compared to the exemplars of catching up, Korea and Taiwan. While at the beginning of the 1970s patenting in the EE as a region was almost ten times higher than Korean patents in the 1990s, Korean patents only surpass the patenting of the entire region, which includes Russia as well (see Figure 5). The falling behind of EE and catching up of Korea and Taiwan began in the early 1970s (see Figure 7). This falling behind is equally present in the small countries, as well as in the three big EE patentors (Soviet Union, Hungary and ex-Czechoslovakia) (see Figure 8).

2.1 Intra-EE differences in US patenting levels and dynamics

A trend of falling behind in the US patenting is characteristic of all EE countries. However, there are significant differences in absolute and relative terms. In terms of absolute numbers of patents, ex-SU, ex-Czechoslovakia and Hungary are the biggest patentors with their cumulative patents between 1969-1996 ranging from 1751 (ex-Czechoslovakia) to 6681 (Soviet Union) (see Table 1). Poland, Bulgaria, Yugoslavia and Romania are very small patentors with their cumulative number of patents below 611 (Poland).

In relative terms (patents per 1m pop) this picture changes somewhat. Hungary with 200 US patents per 1m population is by far the biggest patentor. It is followed by ex-Czechoslovakia (110), Bulgaria (54), ex-SU (24), Poland (14), Romania (14) and Yugoslavia (12) (see Tables 2 and 3).

It is interesting that ex-Czechoslovakia and Hungary have been leaders since the pre-war period where the relative differences between the two groups of countries were similar to today's differences (see Figure 8).

Between 1970 and 1996 this relative ranking remained the same with the exception of the period from 1970-79 when ex-Czechoslovakia, with 69 US patents per 1m pop was the leader above Hungary. Contrary to the general EE tendency of absolute decrease in the number of

FIGURE 7: US FOREIGN PATENTS OF EX-SOVIET UNION, EX-CZECHOSLOVAKIA, S KOREA AND TAIWAN, 1970-1996

FIGURE 8: US FOREIGN PATENTING OF EASTERN EUROPEAN COUNTRIES, 1920-1994

US patents Hungary's patenting continued to rise during the 1980s. Hungary significantly improved its per capita US patenting to 104 per 1m pop, almost five times more than the level of ex-Czechoslovakia, whose US patenting had fallen sharply by the end of 1970s and decreased further in the 1980s.

In the 1990s only Hungarian (126%) and ex-Yugoslavian (268%) patenting has remained above the levels of 1970-79. Ex-Czechoslovakian and ex-SU patenting fell to one fifth of their 1970s levels. In Romania, US patenting almost ceased, falling to one tenth of its low 1970s level. Polish and Bulgarian levels in the 1990s were less than half of their 1970s levels.

In terms of patenting dynamics, rates of small patentors (Poland, Romania, Bulgaria and ex-Yugoslavia) were stagnant throughout the entire pre and post-WWII period. This indicates that in these economies world frontier innovation was very marginal and that the majority of technology effort was behind the world frontier and was of an imitative character. The three 'big' patentors (ex-Soviet Union, Hungary and ex-Czechoslovakia) show three distinct dynamics. Ex-SU patenting rose strongly between 1960 and 1970, than remained on that level until the beginning of the 1980s when fell sharply to the level of Hungary. Ex-Czechoslovakian US patenting rose sharply until the beginning of the 1970s and from that time on fell continually reaching in the 1990s the level of small patenting countries. Hungarian patenting grew much more slowly during the 1960s and 1970s and, quite opposite to ex-Czechoslovakian and ex-SU trends, continued to increase even more during the 1980s. However, by the end of the 1980s and in the 1990s it also fell strongly. In that respect, the falling behind of EE in terms of US patenting seems to be a rather robust feature of the entire region.

Strong decreases in GDP and investment rates have been common to all EE economies, at least until 1993 when recovery began in the central European economies (Poland and the Czech and Slovak Republics). As R&D and innovation activities are a specific form of

investment, which is very sensitive to economic conditions, probably, much more than physical investments, we would expect that the transition has strongly affected US patenting. This is the case in most EE countries (see Table 4).

Table 4: US foreign patents by East European countries (1988-90=100)
(%)

Period	1985-87	1988-90	1991-93	1994-96
Bulgaria	112.1	100	30.3	13.6
Former Czechoslovakia	127.4	100	53.8	51.9
Hungary	115.8	100	74.1	49.1
Poland	97.4	100	53.8	156.4
Romania	500.0	100	150.0	750.0
Former Soviet Union	89.1	100	71.7	27.1
Former Yugoslavia	60.4	100	111.3	122.6

Taking the period before changes (1988-90) as a reference point, decreases in 1994-96 period are strongest in Bulgaria (13.6% of 1988-90 level), Russia (27.1%), Hungary (49.1%) and ex-Czechoslovakia (51.9%). These differences resemble the differences in relative decreases of GDP from their 1989 level. In Poland, US patenting decreased in the period 1991-93 but then started to recover, and is now, not only above pre-1989 level, but is reaching its highest levels to date. This resembles the fast Polish recovery after 1993 as well as the policy of maintaining GERD/GDP levels (Auriol and Radosevic, 1996). Romanian patenting levels are so marginal that any big increases after 1989 are actually departures from zero. Patenting by the ex-Yugoslav republics was strongly dominated by patents from Slovenia and Croatia. These two economies were either not as affected by the war (Slovenia) or by sanctions (Croatia) as Serbia. This, combined with the economic system of the socialist period which was the most open among the EE economies, led to continuity in patenting activities.

Since patenting procedure is a process which lasts at least 18 months, it is still premature to draw conclusions from country differences in US patenting based on 1989-1996 data. As a

hypothesis, data indicate that the recovery in US patenting is related to general GDP recovery and to inherited institutional basis of the US patenting (see section 4).

3 SECTORAL SPECIALISATION IN THE US PATENTING OF EASTERN EUROPE

The sectoral structure of US patenting, indicates areas of comparative advantages and disadvantages and thus may reveal important facets of catching up or falling behind. Catching up is based on an intensive process of, not only intra-sectoral but also inter-sectoral restructuring. In specific historical periods growth is based on specific production factors which affect some sectors more than others (Freeman and Perez, 1988). The mastery of emerging key technologies is indispensable for long-term growth and we expect this to be reflected in US patenting of key technologies. In this section we analyse whether falling behind and prospects for catching-up of EE are linked to the sectoral structure of its US patenting.

A list of the leading patenting sectors of EE countries (based on 99 patent classes) shows two important features (Tables 5 and 6).

First, US patenting of EE economies is dominated by three groups of technologies - mechanical, electrical, and chemicals/drugs. Transport, electronics and 'others' are not among the leading sectors. These three sectors, especially electronics and transport, are in general very poorly represented in EE US patenting. Second, within this general pattern there are important national differences in the extent to which mechanical technologies are present in relation to chemicals/drugs. Hungarian and ex-Yugoslav patenting patterns, where the share of chemicals/drugs is relatively stronger, are the most distinctive when compared to similar patterns in ex-SU, ex-Czechoslovakia, Romania, Bulgaria and Poland, where mechanical groups are more significant.

We have examined the sectoral structure of US patenting by using the Revealed Technology Advantage index. Based on 34 and 99 sectors we grouped areas of the most common RTA and disadvantages (see Tables 7 and 8).[2]

Table 7: Areas of the Most Common Revealed Technology Advantages and Disadvantages (based on 34 tech groups)

Code	Countries	Areas of revealed comparative advantage
12	7	Apparatus for chemicals, food, glass, etc
4	6	Chemical Processes
1	5	Inorganic Chemicals
11	5	Metallurgical and Metal Treatment processes
14	5	General Electrical Industrial Apparatus
16	4	Metallurgical and metal working equipment

Total: 7 countries

Code	Countries	Areas of revealed comparative disadvantage
22	6	Aircraft
29	6	Photography and photocopy
31	5	Miscellaneous metal products
32	5	Textile, clothing, leather, wood products
5	4	Hydrocarbons, mineral oils, fuels and igniting devices
6	3	Bleaching Dyeing and Disinfecting
18	3	Induced Nuclear Reactions: systems and elements
21	3	Other transport equipment (exc aircraft)
24	3	Telecommunications
25	3	Semiconductors
27	3	Calculators, computers, and other office equipment
28	3	Image and sound equipment

[2]RTA = (FPij/Sum(i)FPij)/(Sum(j)FPij/Sum(ij)FPij). RTA = index of revealed technological advantages

Table 8: Areas of the most common revealed technology advantages and disadvantages (based on 91 technological subgroups)

Code	Countries	Areas of revealed comparative advantage
12	7	Apparatus for distillation, mixing, disinfecting, etc
20	7	Electrical-current-producing chemical processes and compounds
1	5	Inorganic Chemicals
9	5	Apparatus for gas separation, vaporization, fluid handling, etc
37	5	Metallurgical and metal treatment processes, metal founding

Code	Countries	Areas of revealed comparative disadvantage
18	7	Mineral oil apparatus
27	7	Superconductors
52	7	Closures and safes
64	7	Other transport equipment parts
51	6	Miscellaneous Metal Products
55	6	Aeronautics
74	6	Radio Communication Systems (inc Radar)
14	5	Distillation Processes
23	5	Photography and photocopy
33	5	Tobacco
34	5	Paper making apparatus
36	5	Printing, type-setting, book making, etc
42	5	Miscellaneous Articles (Jewellery, coffins, bottles, luggage, etc)
49	5	Miscellaneous apparatus (ventilation, coin handling, etc)
61	5	Wheels and axles
63	5	Electricity transmission to vehicles
77	5	Television, facsimile
87	5	Typewriters
89	5	Fabric structures, knots
91	5	Boots, shoes, apparel (products)
93	5	Wood products (beds, chairs, receptacles)

The areas where EE has relatively stronger patenting than the world (excluding US) are: apparatus for chemicals, food, glass, etc; chemical processes; inorganic chemicals; metallurgical and metal treatment processes; general electrical industrial apparatuses; and, metallurgical and metal working equipment. Similar to data based on absolute numbers of

patents, RTA indices show that EE strengths are in mechanical technologies and chemicals/drugs.

In the strongly disadvantaged areas are all the areas where electronics is the basic technology (telecommunications; semiconductors; calculators, computers; image and sound equipment; photography and photocopy). Included in the weak areas is transport, even when we abstract from the naturally low patenting bias of the aviation industry. In the areas of strong comparative disadvantages are the traditional sectors like textiles, clothing, leather, and wood products. However, this does not include any equipment for these sectors, where, particularly in the case of textile equipment, ex-Czechoslovakia is relatively strong in patenting. This is mainly due to patenting of textile equipment which originates from the 1960s.

Within this relatively homogenous regional pattern we can find specific national differences (see Table 9). A correlation matrix based on RTA indicators shows a positive, and relatively high, correlation between sectoral structure of the ex-SU, Bulgaria and Romania. On the other hand, there is negative correlation structure in patent specialisation between ex-SU, and Hungary/ex-Yugoslavia as well as between Romania and ex-Czechoslovakia. A correlation matrix based on share (34 classes) of the total number of US patents is similar to this pattern (see Table 10). It shows a high correlation in patent shares between Bulgaria, Romania, ex-SU and Poland, on the one hand, and between Hungary and ex-Yugoslavia, on the other hand.

How to interpret differences in sectoral specialisations? Are they the result of the inherited industrial structure and 'natural' comparative advantages or do they reflect how close the country was to the Soviet model of development? Based on RTA indices we are inclined to argue that proximity to the Soviet model of development with the emphasis on capital goods industry is more relevant in this case. In terms of a development model Hungary and ex-Yugoslavia were the least Soviet-like economies. Poland started to diverge from the Soviet model in the 1980s.

The impact of this mode of development is most visible in the case of similarity of specialisations of ex-SU, Romania and Bulgaria. If specialisation of Romania and Bulgaria had been based on their 'natural' comparative advantages their RTA patterns would have been more similar to other central European economies than to the ex-SU.

4 INSTITUTIONAL BASIS OF EASTERN EUROPEAN US PATENTING[3]

The institutional basis of the EE US patenting is an important aspect of assessing factors of falling behind by EE as well as of understanding inter-country differences.

The first institutional difference is the share between organisations and individuals in patenting. It should be expected that even in the countries that for quite long periods had limited freedom of business for individuals there was a certain degree of patenting by individuals (see Figure 9).

In the case of Bulgaria, ex-Czechoslovakia and Romania the share of individuals in total US patenting is below 10%. In case of Poland this share is 23%, and primarily reflects the increasing share of patenting by individuals during the 1980s. In the case of ex-Yugoslavia, the share of individuals is much higher (42%). This is the result of two groups of factors. First, IPR in ex-Yugoslavia was not very tight regarding the ownership of patents produced within institutes and enterprises as these could be registered by individuals. Second, unlike other EE countries there was significantly more freedom to communicate and travel, and undertake the patent application procedure by individuals.

Individual patenting in EE countries was a sign of individual entrepreneurship which had been suppressed, during the centrally planned period. Shares of patenting by individuals are

[3]In the classification of individual assignees on institutional sectors we were helped by the following colleagues from the CEE countries: Rossitsa Chobanova (Bulgaria), Helena Glatzova and Hana Slegrova (Czech R), Ildiko Poden (Hungary), Jan Kozlowski (Poland), Irina Roman and Pauna Olarus (Romania) to whom we are very grateful.

FIGURE 9: INDIVIDUALS AND ORGANISATIONS IN US FOREIGN PATENTING, 1969-94

expected and, except ex-Yugoslavia, do not influence the overall patenting picture. However, the situation is vastly different in the case of the ex-SU, where the share of individuals is more than 80%. In this case, patenting by individuals has no indication of free entrepreneurship as the barriers to registering US patents (financial, legal) were such that this share by individuals was possible only through state sponsorship. The case of Russian individual patenting offers an interesting insight into the institutional basis of the ex-SU foreign patenting and innovative activity in socialism, described in the next section.

4.1 Institutional basis of individual US patenting

The high share of US patents registered through individuals can be understood only in the context of state ownership and lack of patent protection in the Soviet system. The costs of US patenting were met by the state whose commission was also to undertake registration in the name of individual patentors. In the case of inventions made in the defence sector, the name of the organisation tended to be omitted so that any of patents from this sector were recorded in the name of individuals (Berry, M).[4]

Censorship for inventions went through several phases in the USSR. Application for a "service" invention was made in the name of the organisation, but after that had to include the names of the actual inventors (Berry, M, *ibid*). In the late 1950s-early 1960s the Soviets were much more liberal in naming the 'zayavitel' or applicant organisation by name (source: Martens, J).[5] However, censorship gradually increased and references to defence-related institutes were omitted so that any patent from this sector was registered in the name of the individuals only.[6] This applied to both foreign and domestic patenting. "About 50 percent of USSR inventors' certificates had no reference to an institute. A small share of these were actually inventions from private individuals. The major part were a mixture of defence-

[4]Based on E mail correspondence. Mike Berry, from Center for Russian Studies, University of Birmingham, is a co-author of 'Science Policy in the USSR', OECD, 1969, Paris. and studied Soviet S&T at that period.
[5]Martens, John, OECD, Paris. Based on E mail correspondence.
[6]In the period from 1989 onwards the share of individuals actually decreased which means that organisations are now becoming more important as patenters.

industrial and civilian organisations but where inventors where not private individuals" (Martens, J, *ibid*).[7] The lack of institutional references may come from the fact that the inventions were not assigned to the institutes in any legal sense, but were simply state property. Thus, there was no compelling reason to list the institute. In many cases the home addresses of the inventors were given (*ibid*).

According to Natalya Ivanova[8] individual patenting abroad received full government support but individuals did not receive all property rights. They signed a special contract with the State Committee according to which government took all the organisational and financial obligations of patenting process and the inventor might receive some financial reward in the case of success with the upper limit of this sum having been predetermined. A special office existed inside the patent office responsible for screening the inventions (normally the inventor in USSR received not a patent but 'avtorskoye svidetelstvo') registering them and selecting the most appropriate for foreign markets and then signing a contract with the inventor. It seems that the option for an inventor to undertake the process of patenting himself was not explicitly prohibited but the obstacles to it were probably insurmountable.

This shows that the distinction between organisations and individuals in the ex-SU foreign US patenting were blurred. In the attempt to commercialise developed technical knowledge the State was directly involved in the application procedure. Has then the mechanism introduced a downward bias in foreign patenting? We think that there is no *a priori* reason to assume that there was a downward bias. Except in cases of military inventions the State was, as in other export activities, trying to commercialise developed inventions. What is distinctive about the Soviet foreign patenting was that it was detached from organisations where patents were developed. This was the case with other export which was detached from enterprises and was the responsibility of foreign trade organisations. However, this

[7]Martens, J. argue that a Soviet inventors' certificate cited as prior art in a US patent usually lists more inventors than are present in the US patent. This difference would come from a quirk in the US Patent Law. Only the true inventor(s) are allowed to be listed as an inventor under the US law. If it turns out that a non-inventor is listed, that can be grounds for annulling the patent. This indicates the nature of co-inventorship in ex-SU.
[8]Based on E mail correspondence. Natalya Ivanova is senior research fellow at IMEMO, Moscow.

institutional *differentia specifica* does not mean that there was a downward bias in patenting in the sense that quality domestic patents were not patented abroad. In fact, the existence of an organisation with an explicit task may have meant that barriers to entry were lower for individuals and organisations.

4.2 US foreign patenting of the eastern European organisations

US foreign patents data show that, besides the ex-SU individual patenting mediated by the State, there were two other countries where institutional basis was peculiarly different. In Romania, the significant share of patents was registered by Ministries. In ex-Czechoslovakia, patents of institutes within the Academy of Sciences were registered as patents of the Academy.[9] However, the scale of these two cases were such that they do not distort the overall picture of organisational structure of US patenting.

In continuation, we analyse the structure of institutional patenting across different types of organisations. While in the case of EE countries, except ex-SU, this may not be a problem we assume that the 27% share of patents registered by organisations in ex-USSR reflects relatively well the overall structure of their US patenting. The organisational structure of US foreign patenting in EE countries shows important institutional differences which have significant implications for the prospects for catching-up as they show different institutional embodiments of innovation activities (see Figure 10).

There are several important institutional differences which formed the basis of the US patenting.

First, differences in the share of patenting by enterprises vs other sectors. In this respect there are significant differences among EE countries. The enterprises are relatively most dominant

[9]This causes very big average concentration of patents in Academy sector. See table 10.

FIGURE 10: INSTITUTIONAL STRUCTURE OF US FOREIGN PATENTING (1969-1994) IN EASTERN EUROPEAN COUNTRIES

in US patenting in Hungary (81% of patents registered by organisations) and Yugoslavia (62%), then in Bulgaria (49%), and ex-Czechoslovakia (42%).

Second, the share of industrial institutes as patentors is the most dominant in ex-SU (56%), and Romania (50%) while it is the least important in ex-Yugoslavia (6%) and Hungary (12%).

Third, the Academies of Sciences are important sources of US patenting only in ex-Czechoslovakia (27%) and ex-SU (15%).

Fourth, only in Romania is the Government, as a registered organisation, an important source of US patenting with the share of 19%.

Fifth, the share of foreign organisations that patented in US from EE was an important in ex-Yugoslavia (28%) and in ex-SU (12%). While in ex-Yugoslavia it was a sign of openness for such activities in the ex-SU it was the scale of the science base that attracted foreign organisations, even at a time when, as economists would say, transaction costs of this operation were non-trivial.

Sixth, the share of patenting by universities is important only in Poland. R&D statistics reflect this share of patenting by Polish universities since the share of universities in Poland was always much higher than the EE average. However, the equally high share of universities in R&D in Hungary is not reflected in US patents. In other countries, especially in ex-SU, and ex-Czechoslovakia, the share of universities in patenting is actually much more significant than their share in R&D would indicate (for R&D data see Auriol and Radosevic, 1996).

These differences in the organisational basis of US patenting are reflected in the list of ten top patentors. There are clear differences between countries in the share of enterprise among the top ten patentors (see Table 11).

In the ex-SU and Romania there is no enterprise among top ten organisations patentors. The top ex-SU patentors are Academies of Sciences and industrial institutes, while in Romania there are central institutes (seven) and government ministries (three). On the other hand, eight out of the top ten patenting organisations in Hungary, and nine in ex-Yugoslavia were enterprises. In the case of Poland there is only one enterprise among the top ten patentors; the three top patentors are universities. This shows that there were important differences among EE countries in how close or far they were from the Soviet model of R&D organisation.

This institutional structure is changing in the post-socialist period in such a way as to become more similar to the institutional basis of innovation activities in other market economies (see Figure 11).

The most common tendencies in institutional basis of patenting are: the increasing share of foreign patenting, which in some countries, like Romania, starts from zero, and the decreasing share of extra-mural organisations (industrial institutes, Academies of Sciences and universities), which are now less important as a source of patentable inventions. The shift in the case of enterprises is not yet clear reflecting the difficulty for enterprises in these economies to embody innovation.

Table 10

FIGURE 11: INSTITUTIONAL CHANGES IN US FOREIGN PATENTING OF EASTERN EUROPEAN COUNTRIES, 1989-94/1969-1988.

Except for Hungary (six) and ex-Czechoslovakia (six) the average concentration of patents per organisation is very low in EE countries (two patents) (see Table 12).[10]

Table 12: Number of US foreign patents per organisation, 1969-1994

Type of organisation	*Former Soviet Union*	*Bulgaria*	*Former Czechoslovakia*	*Hungary*	*Romania*	*Poland*	*Former Yugoslavia*
Enterprises	1	2	6	7	1	1	4
Industrial inst	2	3	5	5	2	2	1
Foreign	1	2	1	1	1	2	1
AoS	2	3	64	3		2	5
HES	2		4	5	1	4	1
Government	2	1		1	5	1	
Non-classified	1		2	1			
Organisations	2	2	6	6	2	2	2

In the former two countries the concentration of patenting is also highest in enterprises and industrial institutes. If we take into account that these two countries have the highest number of patents per capita it would seem that this is based on several organisations having a systematic approach to foreign patenting. In these two countries the patenting shares of the top five organisations were significantly higher than in the ex-SU where patenting was widely dispersed across organisations (see below). This reflects the specific institutional basis of ex-SU foreign patenting which mainly emanated from extra-mural organisations. Similarly, in Poland and in Bulgaria and Romania, where the shares of enterprises was smaller, the concentration of patenting was equally lower.

These inherited differences in the institutional basis of US patenting, and their changes, have important implications for any future patenting activity. Patenting activity in the post-socialist period would be less likely to be damaged if it had previously been done by

[10]Coefficient of US patenting organisational concentration =
= Patents assigned to domestic organisations / Number of domestic organisations

enterprises. In countries where patenting was previously more detached from enterprises, and come mainly from industrial institutes and Academies, it would be expected that the break-up of patenting activity would be more severe. To test for this we constructed a coefficient of 'organisational patenting persistence' which denotes the number of organisations that patented in 1969-1994 divided by the sum of number of organisations that patented only in the 1969-1988 period and organisations that patented only in 1989-1994 period (see Figure 13).[11]

Table 13 indicates that in Hungary and ex-Yugoslavia this share is 14% and 10% respectively. In the case of the ex-SU this coefficient is artificially high as 1989 is not the best dividing line for two periods. These figures indicate that the previous openness and inherited share of enterprises as patentors influences whether organisations have survived or not as patentors in the post-socialist period. That coefficient of organisational persistence in Romania which is zero is not only because of very low patenting by this country but also because it is entirely dominated by ministries and industrial institutes as patentors.

Table 13: Coefficient of 'Patenting Persistence' (CoPP)

	Number of organisations			
	1969-94	1969-88	1989-94	CoPP (%)
Hungary	52	257	105	14.4
Former Yugoslavia	5	30	23	9.4
Former Soviet Union	53	452	155	8.7
Poland	14	175	28	6.9
Former Czechoslovakia	16	213	47	6.2
Bulgaria	12	163	40	5.9
Romania	0	133	5	0.0

[11] Coefficient of organisational persistence in US patenting =
= Number of organisations active in 1969-1994 / (Number of organisations active only in 1969 - 1988 period + Number of organisations active in 1989 - 1994 period)

4.3 Major patenting organisations in eastern Europe

We have pointed out above that in countries where the share of patents originating from enterprises was high the prospects for continuing patenting in post-socialist period are higher than in countries where patenting was mainly from extra-mural organisations. In this section we analyse the major patentors from eastern Europe. In Table 14 we listed 20 major patentors from EE countries in the period 1969-1994, of these 13 are enterprises mainly from Hungary (seven) and ex-Czechoslovakia (five).

The first patentor on the list is the ex-Czechoslovak Academy of Sciences. The process of registration was centralised so it was not possible to get a breakdown of patenting by

Table 14: Top patentors in east European countries, 1969-94

	Organisation	Type	Country	Number
1a	Czeskoslovenska Akademie Ved	AoS	Czechosl	434
1	Richter Gedeon Vegyeszet	E	Hungary	322
2	Chinoin	E	Hungary	290
3	Elitex	E	Czechosl	180
4	Vyzkumny Ustav Bavlnarsky	I	Czechosl	106
5	SPOFA	E	Czechosl	63
6	An USSR Institut Elektrosvarki Imeni EO Patona	AoS	Sov Union	54
7	Vyzkumny A Vyvojovy Ustav Zavodu Vseobecneho Strojirenstvi	I	Czechosl	50
8	Adamovske Strojirny, Narodni Podnik	E	Czechosl	50
9	Tesla, Koncernovy Podnik	E	Czechosl	36
10	Institute Po Metaloznanie I Technologia Na Metalite	I	Bulgaria	35
11	Energiagazdalkodasi Intenzet	I	Hungary	34
12	Eszakmagyarorszagi Vegyimuuek	E	Hungary	32
13	Ckd Prague, Oborovy Podnik	E	Czechosl	31
14	Licencia Talalmanyokat Ertekesito Es Innovacios Kulkereskede	E	Hungary	31
15	Medicor Muvek	E	Hungary	30
16	Institut Gornogo Dela Sibirskogo Oidelenia Akademii Nauk SSS	AoS	Sov Union	29
17	Egyesult Izzolampa Es. Villamossagi Resveny Tarsasag	E	Hungary	26
18	Tatabanyai Szenbanyak	E	Hungary	24
19	Pliva Pharmaceutical And Chemical Works	E	Yugoslavia	23
20	Ministerul Industriei Constructiilor De Masini	G	Romania	23

institutes. It cannot be considered as one organisation the Academy itself being an umbrella organisation.

We believe that Table 14 fairly accurately reflects the main patentors in EE countries, with the exception of ex-SU where individuals rather than organisations were represented. It might be the case that there could be some Russian organisations with a large number of US patents registered through their employees (see discussion above).

Stronger organisational persistence in US patenting after 1989 in countries where patenting was mainly by enterprises is confirmed in the case of the top Hungarian patentors (Table 15). Of these companies, Egis, Alkaloida, and Biogal (pharmaceuticals) and Tungsram (light bulbs) can be considered as rising stars in that their US patenting has actually greatly increased in the post-socialist period. On the other hand, there are no extra-mural organisations whose patenting has increased in this post-socialist period.

Table 15: Major Hungarian US patentors after 1989

	after 1989	% in total	before 1989	% in total
1 Chinoin	75	14.9	215	13.8
2 Richter Gedeon	69	14.1	253	16.2
3 Egis	41	8.2	7	0.0
4 Tungsram	22	4.3	9	0.0
5 Alkaloida	17	3.4	11	0.0
6 Biogal	12	2.4	11	0.0

Like to Hungary, in ex-Yugoslavia US patenting was strongly based on enterprises (Table 16). Among the top patentors we can find three pharmaceutical companies from Croatia and Slovenia and one electrotechnic company from Slovenia. Also, companies continued to patent in post-1989 period.

Table 16: Major patentors from ex-Yugoslavia, 1969-1994

Company	Sector	No	% in total
1 Pliva	pharmaceuticals (Croatia)	23	8
2 Lek	pharmaceuticals (Slovenia)	21	7
3 Iskra	electrotechnics (Slovenia)	14	5
4 Krka	pharmaceuticals (Slovenia)	8	3

In Poland there is no industrial enterprise among the top 25 organisations in 1969-1994 period. The top three patentors are Gdansk, Warsaw and Slaska Polytechnics with relatively small shares in total patents (see Table 17).

Table 17: Major Polish US patentors before 1989

	Before 1989	% in total	After 1989	% in total
Warsaw Polytechnics	19	3.8	0	0
Gdansk Polytechnics				
- Institute of chemistry and technology	17	3.4	3	5.0
Slaska Polytechnics	14	2.8	1	1.7
Central R&D unit for machine equipment	10	2.0	10	

The most important sources of US patenting in Poland, after individuals, are universities, central R&D institutes and Academy institutes. Even after 1989, the dominance of universities and institutes remained unchanged. Whether this says something about the sustainability of current Polish recovery compared to Hungarian, would require a more research.

In ex-Czechoslovakia, US patenting was dominated by the Academy of Sciences (AoS) and central institutes, and was also concentrated in some industrial firms (Table 18). After 1989, patenting by enterprises continued, although unlike in Hungary, there were no rising stars or increased patenting by companies in post-socialist period.

Table 18: Major ex-Czechoslovak patentors before 1989

	Type	Before 1989	% in total	After 1989	% in total
Elitex	E	162	10.3	16	10.7
Vyzkumni Ustav Bavlnarsky	I	99	6.3	6	4.0
Spofa	E	58	3.7	5	3.3
Vyzkumni a Vyvojovy Ustav Zavodu Vseobceheno Strojirenstvi	I	50	3.2	0	0
Adamovske strojirni, Narodni Podnik	E	49	3.1	1	0.6
Tesla, Koncernovy Podnik	E	34	2.2	2	1.3

E = enterprise; I = independent institute

In Bulgaria, US patenting has highest in R&D institutes and industry with two institutes and two enterprises making up the top four. In Romania, US patenting was, and is still, marginal. This is a consequence of the 'delinking' that started under Ceausescu in 1981 and indicates the difficulties involved in reintegrating the country into world technological activities. US patenting was dominated by central industrial institutes and Ministries. Romania is the only EE country where the top patentor was a ministry (The Ministry for Machine Building with 23 patents).

US patenting by organisations in ex-SU was almost completely by Academies of Sciences and R&D and design institutes (Table 19). There were no industrial enterprises among top patentors which does not mean that there were no patents registered through individuals who came from either civil or defence enterprises. In this respect our picture of major patenting organisations may be distorted to an unknown extent. However, very low patenting in the 1992-94 period, when the old system had ceased to exist, has not led to any significant patenting by Russian enterprises. As in other countries where patenting was dominated by extra-mural organisations, US patenting by the ex-SU is widely dispersed. Patents from top organisations in both periods represent less than 1% of total patenting.

Table 19: Major patenting organisations in ex-USSR

Before 1989	No	After 1989	No
1 AN USSR Institut of Elektrosvarki Imeni E A Patona	48	1 AN USSR Institut Elektrosvarki Patona	6
2 Institute 'Gornogo dela' Sibirskogo Odelenia AN USSR	29	2 Institute for problems of modelling of AoS	6
3 Vsesojuzny Nauchno-Issledovatelsky i Proektno-Konstruktorsky Institut	22	3 Technalum Research Inc	6
4 Gosudarstvenny Nauchno-Isledovatellsky Institut	20	4 All-Soviet R&D institute	4
5 Vsesojuzny Nauchno-Isedovatellsky Institut Legkogo	20	5 All Soviet R&D and design bureau	4
		6 Kharkovsky Aviatsioniny Institute	4
		7 Plasma Plus	4
		8 Principia Optics, Inc	4

4.4 Foreign patenting

As pointed out earlier, the overall number of foreign patents in EE, with exception of ex-Yugoslavia and ex-SU, was marginal. After 1989 there are signs of increasing presence of foreign companies as patentors. However, starting levels are very low so one should not read much into these increases. For example, BASF in Hungary registered four patents. In Poland the foreign leaders are ABB and Bayer with two patents each. In ex-SU there were 80 US patents registered by foreigners in the period 1969-88. In the 1989-1994 period, the total number was 20, which may indicate increasing interest by foreigners to exploit the Russian science base although this is still a very low number for the scale of Russian R&D. Romania is the only EE country where foreign patenting existed neither before nor after 1989.

5 CONCLUSIONS

1 Although most of the Eastern European economies were closed economies their US foreign patenting was not below the levels of comparable market economies. The US foreign patenting stocks of EE conform broadly to their income levels. The dynamics of the EE US patenting correspond to the general loss of steam of EE economies since the mid-1970s. Decreasing rates of growth since the mid-1970s are broadly compatible with the falling trend in US patenting.

2 The levels and dynamics of US patenting of EE as a region seem to be determined more by income levels and growth rates than by specific features of socialist economic system. Inter-country differences in patenting levels (cf big vs small country patentors) originate from the pre-WWII period and cannot be ascribed to specific differences in the socialist period. On the other hand, differential rates of patenting within a similar general trend suggest that systemic differences between individual EE countries play a role in explaining differences in patent dynamics. Probably, systemic factors should be seen in the context of other factors. Several factors that may contribute to an explanation: different industry profiles, different degrees of openness of economies, different degrees of bias in the economic system towards the Soviet economic model, and different policies in different countries regarding US patenting. We are unable to give a full explanation of these differences as this would require a much more thorough analysis of EE economies and particularly their specific past policies in relation to US patenting.

3 Despite the closed character of their economies in the socialist period state policy allowed and supported the sale of technological knowledge abroad. This ranged from more or less independent patent activities by enterprises in Hungary, and, especially, ex-Yugoslavia, to controlled state sponsorship in the case of ex-SU or even direct State involvement in patenting process, as in Romania.

4 The US foreign patent stocks of EE economies reflect more their past capabilities than present strengths. The technological advantages of EE economies are firmly rooted in their

past successes and are very much based in metallurgical and mechanical technologies, and in chemicals/drugs. Absolute and relative levels of patents in electronics are marginal.

Within this common regional pattern there are three groupings of countries with similar patenting profiles. The first is specialisation in metallurgy and general industrial apparatuses of ex-USSR, Romania, Bulgaria and to a certain extent of Poland. The second, is the patenting profile of ex-Yugoslavia and Hungary, where drugs play a dominant role. Thirdly is the profile of ex-Czechoslovakia where mechanical engineering represents an important share in patenting.

5 There are significant intra-regional differences in the institutional basis of US foreign patenting which broadly follow inter-country differences in the institutional structure of R&D.

There are two relatively discernible groupings of countries in terms of whether their patenting relied more on enterprises or on extra-mural organisations. In ex-Yugoslavia, Hungary and ex-Czechoslovakia patenting was mainly by enterprises while in other countries US patenting originated mainly from extra-mural organisations (Academies of Science, R&D institutes and design bureaux in ex-SU; central institutes and government in Romania; industrial institutes and enterprises in Bulgaria; and universities and industrial institutes in Poland).

There are a few common patterns in transformation of sources of US patenting in the post-socialist period. The increasing role of foreigners and enterprises, and the decreasing role of extra-mural organisations indicate that, institutionally, innovation activities are converging with a market-economy model.

6 The underlying motive of our analysis was the likelihood of EE following either or both of the two aforementioned paths of technological modernisation (see introduction). Either the Chinese model of recombination of technological capability or the east Asian

inverse life cycle model? Based only on US patent data our conclusion is that the basis for catching up of EE based on world frontier patentable innovation is rather tenuous. The remaining strengths are in specific areas but not across broad sectors or the whole industry. For example, in ex-Czechoslovakia, patenting is still strong in textile manufacturing equipment, in Hungary patenting is developed in drugs and organic chemicals, in Russia is in mining and metallurgy equipment and processes. This means that the possibilities for patterns which would recombine world frontier R&D, design and manufacturing capabilities are not likely on a large scale but seem probable in the specific sectors in which these economies still have world frontier patentable inventions. On the other hand, the inverse life cycle pattern does not seem likely to be a general pattern. The level of human capital and over-expanded R&D, design and engineering capacities indicates opportunities which go beyond this pattern. This stems from the main EE problem, which is not development, but restructuring.

7 These conclusions should be seen in the light of the limitations of our analysis. Data used take into account only patentable world frontier innovative capabilities. They do not include software capabilities and this may underestimate EE capabilities in electronics. Since military considerations played a crucial role in R&D in the past this may be an underestimation of the opportunities arising from conversion of R&D capabilities in defence sector. Finally, catching up can be sustained for some considerable time through technological modernisation which is not at the world innovation frontier. For example, world frontier innovative capabilities in electronics are not a precondition for catching up in electronics. US patent data shed light on one aspect of EE catching up but they do not provide the entire picture.

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