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Patterns of Innovative Activities in Countries of Central and Eastern Europe: an Analysis Based on Comparison of Innovation Surveys

1. Introduction

The transformation of the economies of central and eastern Europe is accompanied by changes in the patterns of their innovation activities. In the socialist period the innovation activity was organised and undertaken across a range of different institutions like ministries, branch institutes, Academies of Sciences, etc., whereby enterprises were not in the control of the whole innovation process. They were dominantly production units with very often limited responsibilities for innovation and R&D process, in particular. With the opening and marketisation of the ex-socialist economies and the dissolution of the former S&T system enterprises had to embody the majority of innovation activities.

Our understanding of this process is still very unsystematic, partly, due to limited data on innovation activities. With the introduction of large scale national innovation surveys in Russia, Poland and few other small scale surveys undertaken within the academic research in other CEECs it became possible to explore the innovative behaviour of enterprises on a more systematic grounds. First analyses along these lines are Glaziev et al (1997), Gokhberg and Kuznetsova (1996), (1999), Niedbalska (1999), Inzelt (1999). These analyses are confined to individual countries and we still do not have any comparative insights. Numerous methodological problems and difficulties in interpretation of different national surveys make such analysis difficult and hazardous. In this paper we try for the first time to compare the available innovation surveys from

central and eastern European countries (CEECs) as well as compare them with the results of the EU - CIS (Community Innovation Survey). Such analysis is relevant from the policy perspective but also from the following two academic aspects.

First, in terms of levels of development CEECs are far behind the EU as their GDP per capita ranges from 14% (Ukraine) to 63% (Slovenia) of the EU average. Innovation surveys allow us to explore whether this common feature of the region - its relative backwardness in relation to EU - has effects on innovative activities in terms of their scale, scope and structure. Are the shares of innovative enterprises different in CEE than in the EU countries? Whether the nature and patterns of innovative activities reflect differences in development levels?

Second, the specific transitional environment of the CEE economies with pervasive institutional uncertainties, blurred ownership boundaries and undeveloped capital markets is probably not very conducive to the long-term nature of innovation. However, we still do not know whether the specific institutional environment of the post-socialist economy influences the innovation activities in terms of their objectives, hampering factors, sources of ideas, etc.? Are the differences in institutional reforms and recovery between central European (Poland, Hungary, Slovenia) and eastern European countries (Romania, Russia) visible in the innovation activities?

As we already pointed the analysis based on innovation surveys is still burdened by methodological and interpretative problems. Comparisons of national surveys furthermore magnify these problems. In the next section we analyse some of these methodological problems although we will have to come back to them several times during the analysis.

In the third part we undertake comparative analysis across the several dimensions of innovative activities (spread and types of innovative activities; sectoral differences; objectives, sources of information, etc.). In the fourth part we summarise the main results and develop conclusions.

2. Methodological Issues

Innovation surveys are a new source of information on the technical change. It has been realised some time ago that the R&D do not tell the whole story about technical change, as the innovation is essentially an interactive process, which involves a variety of types of knowledge and sources. The multiform nature of innovation activities and their sectoral specificity have been

explored in by now already a large literature. Pavitt (1984), Kline and Rosenberg (1986) and von Hippel (1988) are only the most known examples of research on innovation from this perspective.

As any indicator, innovation surveys have their advantages and disadvantages. These have been analysed extensively by Archibugi and Pianta (1996). For the time being, innovation surveys are not yet fully harmonised although Oslo Manual (OECD, 1991) is accepted as an international standard in this area.

The CEECs have been collecting data on newly developed products and processes for a long time during the socialist period. In former socialist countries, innovations were recorded through indicators like "New prototypes of machines, equipment, apparatuses, instruments and automation means", "Duration of development of new prototypes of machines, equipment, apparatuses, instruments and automation means", and "Utilisation of new prototypes of machines, equipment and apparatuses" (accepted for serial production or individual production for research and for export). These product innovations are defined as being developed in the country for the first time and being essentially different from the previously manufactured ones by principle of operation and functional destination. These data were the basis of innovation statistics in centrally planned economies and were confined on product innovations, particularly on machinery products. Reporting these innovations was mandatory. For example, in the case of the former USSR data series have been existing since the early 1970s.

Despite the long practice of collection of innovation statistics, the nature of these statistics is very much different when compared to current innovation surveys. In this case conceptual and methodological differences are strong. The system in centrally planned economies did not look at the innovation process and the structure of innovation activities through indicators like R&D, patenting or publications. The objectives of innovation and hampering factors as well as the forms of technology transfer were not monitored. The counting of product and process innovations, many of which were not implemented, did not reveal the true innovation capacity of these economies. In that respect counting innovations many of which were never implemented indicate methodologically different units of measurement when compared to modern innovation surveys.

It was only recently that the CEECs started to collect innovation data within the framework of innovation surveys. In this endeavour they enjoyed some of latecomers' advantages as they all relied on Oslo Manual methodology and benefited from the experiences of other national surveys within the EU. On the other hand, they also all adapted to different degrees the Oslo Manual methodology to their national circumstances. This does not ensure full

comparability and the methodological differences remain important in understanding data. In this section we point to some of the methodological differences and problems in applying innovation surveys in the CEECs.

We already pointed to the important biases of innovation surveys, which come from subjective nature of many of the questions. Subjective responses on questions regarding the objectives, hampering factors, sources of information as well as on questions like share of sales based on new products are not only the CEE' specificity. These have been noticed in almost all analyses of the CIS data.

Among the methodological problems the most important are the following. First, the share of innovating firms, as an indicator of the spread of innovation activities, has several biases. The most important are: i) they do not take into account that innovations are of unequal value and that the number of innovations can differ significantly among firms[1] (weight insensitivity), ii) not every year the innovation occurrences are the same (time bias), iii) the numbers may simply reflect the concentration of firms in an industry/country (deconcentration bias). Namely, surveys ask establishments which may belong to one or separate companies. In the first case innovations in two establishments of the same company would be counted as one innovative while in other case as two innovatives.

Another problem is that the samples can be biased towards innovating firms. For example, Evangelista et al (1997) reports that in the case of the first CIS innovation survey there is a negative correlation between response rates and percentage of innovating firms across countries.

The second problem is that definitions of innovation may not be identical. The Polish survey includes organisational innovations into survey when they are related to technical innovations. The lack of organisational innovations is a weakness of Oslo Manual and this discrepancy may be considered as an advantage. Nevertheless, this positive difference reduces full comparability between Polish and other surveys.

Innovation surveys in Russia show that the diversification is often interpreted as innovation (Gokhberg and Kuznetsova, 1996, p. 14) (Kuznetsova, 1998). To overcome this problem Russian survey introduces a third category in the full scale survey: 'other innovation products' whereby marginally improved products are recorded. Also, this category includes products based on borrowed non-patented rights. This not only expands the notion of innovation but in the structure of innovation costs of the Russian survey there is a new item 'acquisition of non-patented licences, know-how, other technologies from

[1] The first Polish innovation survey tried to overcome this by requiring data on the number of innovations in an individual enterprise.

unaffiliated institutions, enterprises or individuals' (Gokhberg and Kuznetsova, 1996, p. 15).

The second definitional difference in the Russian innovation survey is that innovation is not only defined at its final stage when the equipment is already in operation, i.e. the production is settled and products are manufactured. But, 'the initial and interim stages of introduction are also registered, when for example, a new equipment is still being assembled or is ready for exploitation but not yet started, has not been tested in action and is not engaged in products manufacturing' (Gokhberg and Kuznetsova, 1996, p. 7) (Gokhberg and Kuznetsova, 1999, p. 7). They lead to four categories of enterprises: those i) Active in innovation; ii) Inactive in innovation, iii) Planning innovation activity in the near future, and iv) Engaged in the main kinds of innovation activity (Gokhberg and Kuznetsova, 1999a, Knell). These two definitional differences could overestimate somewhat a number of innovations in Russia.

Third, an important weakness of innovation surveys is that they do not measure the weight of innovations. Surveys do not take into consideration different scales of different innovations and hence these should be treated as proxies rather than as direct measures. The dominance of the numerical approach to innovations is present in the most of the CEE' surveys and probably reinforces, as pointed by Gokhberg and Kuznetsova (1996), the tradition of domestic statistics.

This weakness is partly overcome through data on the share of sales based on new products, but these exclude process innovations, which are important in the CEE countries. On the other hand, process and product innovations usually accompany each other as we show later on. The new products require a new production method, while new processes are hard to introduce without changing their products (Mohnen and Dagenais, 1998).

We also include into comparison the two Yugoslav (Serbian) surveys, which refer to the 1987-1991 and 1991-1995 periods. From being a semi-command but open economy during the 1980s, the part of the ex-Yugoslavia (Serbia) became economically isolated through international sanctions. This rare shift from open to isolated economy, which resembles features of closed economy, represents a unique example for observing changes in the innovation activities. We use this example as a control case for understanding the inverse shift from closed to open economy in the rest of the CEE.

3. Results of the Comparative Analysis

3.1. The Spread of Innovative Activities

The proxy for the spread of innovative activities is the percentage of innovating firms over the total number of firms. Innovating firms have been defined as those that have introduced at least one product or process innovation over the period analysed. Although we pointed to several drawbacks of it, this indicator is extremely important for understanding the scale of innovative activities in CEECs in a period when enterprises are faced with the pressures of large scale restructuring.

Table 1. Shares of innovative firms in EU and CEECs

Ireland	0,72
Germany	0,67
Poland I *a*	**0,619**
Belgium	0,61
Netherlands	0,57
Denmark	0,56
Norway	0,53
EU	0,5
France	0,39
Poland II *b*	**0,376**
Spain	0,37
Luxembourg	0,37
Italy	0,34
Slovenia	**0,319**
Romania	**0,283**
Russia I c	**0,224**
Russia II d	**0,06**

a 1992
b 1994-96
c 1992-94
d 1995-96

The shares of innovative firms in CEECs are clearly below the EU average of 53% of innovative firms. Moreover, they are clearly at the bottom of the EU league. This conforms to overview of enterprise case studies in the CEECs, which suggests that the most often form of restructuring is passive

adjustment, not deep restructuring (Carlyn et al, 1995). The introduction of innovation by definition requires a deep organisational change and long-term horizon, two objectives which are difficult to meet in the current institutional environment of the most of the CEECs.

A second feature of table is that ranking of the four CEE countries is very closely related to their growth rates[2]. When we correlate the shares of innovative firms with the levels of GDP in 1997 compared to their 1989 levels we get a very high correlation coefficient of 0.96[3]. This may suggest that broadly perceived innovative dynamics or the share of firms, which are involved in innovative activities, is closely related to the dynamics of economic recovery.

The third feature of this table is that in both Poland and Russia the share of innovative enterprises between the beginning of the 1990s and mid-1990s has dropped down. In Poland the share of innovative enterprises dropped from 62% (1992) to 38% (1994-96) while in Russia the share dropped from 22% (1992-94) to 6% (195-96). How do we interpret this downward fall in the scale of innovation activities in two countries with such a different economic situations? Does it contradict to a strong correlation between the rate of economic recovery and the scale of innovative activities mentioned before? Apart from methodological differences, to some of which we pointed in the previous section, we should bear in mind that the shares of innovative firms do not reflect the economic relevance of innovative activities, but indicate the extent of search efforts by enterprises. A high share of enterprises doing innovations does not mean that the share of sales based on innovations should be also high.

The general downward trend in the scale of search efforts of enterprises seemed to be accompanied by an increasing polarisation in the scale of innovative activities across individual sectors. In the case of Poland, in 1992 the most innovative sector had 80.1% of innovative enterprises while the least innovative had 49.5%. In the 1994-96 period the difference was 78% vs. 8.3%. So, the intersectoral differences in the scale of innovative activities have broadened from 30.6 to 70.3 percentage points. This polarisation in the scale of innovative activities suggests that at the outset of transition most of the enterprises, irrespective of difficulties, were searching for new products and processes. However, the search process became highly differentiated across different sectors as some sectors have managed to transform innovations into sales while others did not.

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[2] Here we compare only the results of the second Polish and Russian innovation surveys.

[3] Indexes of economic recovery 1997/1989 is for Poland 111.8, Slovenia 98.3, Romania 82.5 and for Russia 57.5. Source: WIIW database, May 1998 and OECD Economic Outlook, June 1998 based on Hutschenreiter, Knell and Radosevic (1999b).

Explaining the share of innovative enterprises

A socialist system was characterised by a weak in-house innovative activities of enterprises (Freeman, 1999). In the post-socialist period the enterprises are embodying innovation by building their own R&D and technological capabilities. However, this process differs considerably between countries and the innovation system in CEECs carries still strong features of the past (for detailed accounts of this process see Radosevic (1998), (1999), (1999b). While extramural R&D activities are gaining in importance, there is still a strong dependence, in particular of the ex-Soviet Union countries on extramural R&D. For example, out of 3803 innovative enterprises in 1992-94 in Russia 1788 have received unpatenteed licences, which includes R&D contracts and purchase of industrial know how, etc (Gokhberg and Kuznetsova, 1999)[4]. These are mainly the R&D results of industrial institutes which often operate in quasi-arm's length relationships with enterprises. In order to explore the determinants of the innovative activities in the post-socialist period we use sectoral data on the share of innovative enterprises, enterprises with in-house R&D activities, with contracted R&D, and those that purchased industrial know-how from extra-mural organisations. These data are available only for Russia and therefore the results may not be applicable to other CEECs. First, we regress the share of enterprises with in-house R&D activities on the share of innovative enterprises. This should indicate the extent to which the scope of innovative activities is dependent on the scope of in-house R&D activities.

Y = 11.1 + 0.785 X1

t-stat (2.34) (4.5)

Prob (0.037) (0.000)

R2Adj. 0.6

Y = share of innovative enterprises

X1= share of enterprises with in house R&D

The result is that 60% of variation in the share of innovative enterprises can be explained by the share of R&D activities. However, a very high intercept coefficient suggest that there is a high share of innovative activity which is 'autonomous', i.e. which cannot be explained by in house R&D activities. Therefore, we test the relationship in which the share of innovative enterprises is determined not only by in house R&D activities, but also by the share of enterprises that had R&D contracts or that purchased industrial know-how.

[4] According to Gokhberg and Kuznetsova, (1999, Knell) only 5.8% of innovative Russian enterprises use patent licences and 10.3% patent rights.

Y=0.549X1 + 0.207X2 + 0.35X3
t-stat (1.98) (1.43) (2.39)
Prob (0.07) (0.180) (0.036)
R2Adj. = 0.75
Y = share of innovative enterprises
X1 = share of enterprises that acquired industrial know-how
X2 = share of enterprises that contracted R&D
X3 = share of enterprises with in-house R&D

As expected, the explanatory power of the regression has increased but the significance of the coefficients has declined suggesting that the two variables for extra-mural innovative activities may be correlated. Indeed, their coefficient of correlation is 0.86. The regression where the share of innovative enterprises is a function of two types of extra-mural R&D activities has high coefficient of determination, but the coefficients are not significant at 5% level.

Y = 0.6661X1 + 0.342 X2
t-stat (2.04) (2.13)
prob (0.06) (0.05)
R2Adj = 0.70
Y = share of innovative enterprises
X1 = share of enterprise that acquired industrial know how
X2 = share of enterprises with contract R&D

In order to take into account the role of both extra- and intra-mural R&D and to avoid the problem of multicolinearity we simply drop the acquisition of industrial know how as a variable and leave contract R&D to carry the proxy of extra-mural innovation activities.

Y= 0.09X1 + 0.162X2
t-stat (4.91) (2.467)
Prob (0.00) (0.03)
R2 adj. = 0.75
Y = share of innovative enterprises
X1 = contract R&D
X2 = in house R&D

The result is a robust regression, which suggests that both, extra- and intra-mural R&D activities play a role in the innovative activities of enterprises. First, the combination of extra-mural and intra-mural R&D activities explains 75% of variation in the share of innovative enterprises. Second, almost two times bigger coefficient for in-house R&D than for contract R&D suggests that the Russian innovation system is moving towards the situation where in-house R&D activities of enterprises are playing more important role than the extra-mural R&D activities. However, the role of extra-mural R&D activities still continues to be significant, suggesting that some elements of the Soviet R&D model as described by Gokhberg (1997) are still operating. This also conforms to our more descriptive accounts of R&D in the CEECs (see Radosevic, 1999).

3.2. Firm Size and Innovation

During the socialist period small firms were absent in the industrial structure. This phenomenon became known as 'the socialist black hole' (Petrin and Vahcic, 1988). In the post-socialist period we have seen a fast growth of small firms in all CEE countries. While in this respect the industrial structure is becoming more heterogeneous, it is not yet clear what is the role of small firms in innovation dynamics of these countries. For example, in the case of Hungary Gabor (1997) argues that small firms are technologically inferior and that they operate in an emerging dual economy. On the other hand, SMEs are regarded as the main sources of growth in CEE economies (for example, see World Bank, 1996). While the role of SMEs seems undoubtful in terms of employment and income generation, it is much less clear what is their role in generation of innovations in CEECs. Are examples of dynamically growing SMEs in sectors like software or PC assembly exceptions or signs of a broader tendency?[5]

The large socialist firms are usually portrayed as a burden for the economy due to their monopoly power, lack of entrepreneurship or the ability to capture the government. This view became the most obvious in the privatisation process whereby large socialist conglomerates were usually split into more viable units. To the largest extreme this process has taken place in eastern Germany, (see Meske, 1997, and Grenzmann, 1999) where large firms are now absent in the industrial structure. This has seriously undermined the scale of innovation activities in this economy. In other CEECs this tendency varies from country to country; it depends on the dominant mode of privatisation, and whether governments are keen to save 'national champions' or privatise them as

[5] Kubielas (1998) provides a good account of the growth of the PC assembly and software industries in Poland whose growth is very much based on small firms and alliances.

a whole. So, the question of firm size and innovation in CEECs has a direct relevance for assessing the changing industrial structure.

In assessing the role of different firm sizes in innovation dynamics of the CEECs some of the recent results of their role in the EU countries should serve as a useful reference point. The EU innovation surveys show that we should sharply distinguish the population of innovative from non-innovative small firms (EC, 1997). SMEs which introduce innovations are not substantially less innovative than their larger counterparts. Data from the Italian innovation survey shows that innovation expenditures per employee vary from 18.3m liras for large to 14.7m liras for small firms (Evangelista al, 1997). In that respect, one could argue that large firms do not have inherent advantages. When EU firms introduce innovations, they invest amounts of money in the range of 8% to 10% of their sales independently of their size (Evangelista et al, 1996, Figure 11). Total innovation costs per sales for 8729 EU innovating firms are similar across different size groups. In case of R&D/sales bigger firms do invest somewhat more. However, in terms of innovation expenditures per employee for both innovative and non-innovating firms large firms turn out to be significantly more innovative. The innovation expenditure per employee of Italian firms are 16.7m liras for large vs. 4.0m liras for SMEs (Evangelista at al, 1997). So, for the population of both innovative and non-innovative firms the positive relationship between innovation intensity and firm size strongly re-emerges. However, there is not clear correlation between firm size and share of innovation costs in relation to sales. For the EU sample as a whole large and small firms have a higher share of innovation outputs (measured as a share of sales based on innovative products) than medium sized firms (Calvert al, 1996, p. 20). In this case the distribution is not linear in favour of large firms, but U-shaped. The analysis by Tether (1998) shows that it is important to bear in mind the differences in the values of innovations generated by firms of different sizes as the value of innovations tended to increase with the size of the innovating firms.

The available data for the CEE do not allow us to examine the relationship between firm size and innovation to an extent that it has been done within the EU surveys. However, the limited available data do provide us with some new insights. The share of innovative firms is significantly larger in the group of large enterprises even though we could not make full comparisons due to different national classifications. In that respect the firm size - innovation relationship in CEECs seems to be the same as in the EU economies[6]. The only difference between the EU and CEECs is a very low share of small innovative firms in the category of up to 50 employees in the CEE. In Romania and Russia

[6] For the time being we abstract of the data from the first Polish innovation survey.

the shares of innovative firms in this group are 2.7% and 4.9% respectively. In Slovenia and in Poland (1994-96 survey) their share is 14.2% and 16% respectively. This is in stark contrast to EU where the share of innovative firms in this group is 44%. If we take into account that the share of firms in this category of enterprises in CEECs is significantly smaller than in the EU, this difference becomes even more pronounced. This suggests that the share of new technology based firms which are usually in this category is extremely small in the CEECs.

So far we have abstracted of the results of the first Polish innovation survey which shows a very high share of innovative small firms in the group between 6 - 50 employees. How do we explain the decreasing share of innovative small enterprises in this group in Poland whose 48% share in 1992 was higher than the share in the EU of 44%? The data for Poland for the period between the two innovation surveys show that the share of small innovative firms has fallen by 77% while the share of innovative large firms has fallen by only 5%. Is it a sign of deteriorating innovative dynamics of SMEs in Polish economy or something else? Since the Polish economy was growing in the 1992-1994 period by 3.9% on an average, this decrease is hard to attribute to a decrease in innovation dynamics. We pointed in the section 3.1 that the decrease in the share of innovative firms might be a general trend in the CEEC which suggests that much of innovations at the outset of transition could not be transformed into viable commercial products later on. Second, as pointed out by Calvert et al (1996, p. 20), small firms are often new firms which come into being to sell new products and hence by definition a greater share of their output would be innovative. At the same time, the change of their products should be much slower than in the large firms due to their limited economies of scope. Assuming an increase in the birth rate of SMEs we would expect the unchanged share of innovative SMEs. However, a big difference in the share of innovative SMEs between the EU and CEECs, including Poland in the second survey, suggests that the mechanism of generation of small firms in CEE is not working as in the EU. Also, this may suggest that the small firms are not introducing new innovative products at the same pace as in the EU countries.

An interesting question for public policy is whether the relationship between firm size and innovation holds for the public as well as for private enterprises? The data for Poland show the distribution of the shares of innovative firms across different firm sizes and public/private ownership: there is not significant difference in the shares of innovative firms between public and private enterprises. In all groups, except partly in group of medium-sized enterprises, differences in the share of innovative enterprises are negligible.

A single factor analysis of variance shows that the variation across firm sizes is much more significant than the variation across ownership.

In conclusion, the innovation and innovation expenditures in the CEE continue to be concentrated in large enterprises. In this respect the CEE conform to a general situation in market economies. This also suggests that the principle of privatization in the CEECs, whereby a big size of enterprises is *a priory* a problem, is likely to generate weaknesses in the industrial structure, as we have seen in the case of eastern Germany. Innovation dynamics in the economy depends on the high share of innovative firms in all classes. So, the problem in the CEE seems to be much more a low share of innovative firms in general rather than in a particular size groups.

3.3. The Structure of Innovation Expenditures

The differences in the structure of innovation expenditures should indicate differences in the main types of innovation activities. Taking into account differences in developmental levels between the EU and the CEE we would expect that the structure of innovation expenditures should be significantly different. Countries that are behind the technology frontier should spent relatively more on embodied technologies and on downstream innovation activities like reverse engineering, product and process imitation rather than on world frontier R&D.

The analysis of the innovation expenditures by Evangelista et al (1996) shows that, first, the distribution of innovation costs is relatively coherent over all EU countries. If costs reflect well the scope of different innovation activities, then the mix of innovative activities appears rather similar across EU countries. The second conclusion based on the EU innovation survey is that the industrial innovative process consists, first and foremost, of the purchase and use of 'embodied' technologies (innovative machinery and plants), which account for 50% of total expenditures on innovation (ibid). Third, among the 'intangible' innovation expenditures R&D activities are confirmed to be a central component of the technological activities of firms (see Evangelista et al, 1997, fig 2., p.529). Fourth, across all European countries expenditure wise, the acquisition of 'disembodied' technology through patent and licences, emerges as a secondary innovation component when compared to the technological sources (ibid).

If we compare only the data for Poland, Romania and Russia with the EU data they show that the innovative expenses in CEE are significantly more devoted to purchase of embodied technologies. The share of R&D&E activities is more than two times smaller than in the EU. These data seem to be consistent

with the data on the number of enterprises involved in R&D activities in CEECs, which we analyse in section 3.4. They also confirm our proposition from the beginning of this section that the latecomer countries should have a different cost structure of innovation expenditures. However, Slovenian data seem to be either inconsistent or reflect rather different situation. We believe that they do not reflect under-investment into embodied technology in Slovenia, but the differences in the 'coverage' of investments, which are linked to innovative activities. If these figures were reflecting a fully comparable situation, then we would conclude that the innovative activities in Slovenia are mainly focused on R&D and that there is a serious problem of physical underinvestment in this country. However, the average growth rate of investment into gross fixed assets in Slovenia between 1993-97 was 10.6% while the share of investments in GDP was 26.5% in 1995[7].

In order to ensure larger comparability, we compare innovation expenditures reduced to 'intangible' investments. Our attempt to regroup expenditures to ensure comparability could not resolve all methodological differences. First, high share of R&D for Slovenia (75%) and Romania (65.4%) seems to be exceptionally high when compared to other CEE countries as well as when compared to EU. In the case of Romania that is partly the result of grouping market research cost into R&D (see CSO, 1995). In Slovenia, the share of engineering costs is unusually low and it is very likely that the part of engineering costs is not included in engineering costs. The original Romanian data do not contain engineering costs but very high share of 'other' costs, which we grouped into engineering costs. We did the same for all other countries as the engineering costs represent all 'downstream' activities after R&D, excluding marketing and costs of purchasing patents, licences, etc. This conforms to our expectations regarding the position of the CEECs as catching-up countries. However, the picture is not so neat as the R&D share in innovative expenditures for some EU countries is similar or even below the share of the CEECs. Hence, the low share of R&D in innovation expenditures of CEECs applies only as a rough tendency in relation to the EU[8].

[7] Sources; EBRD (1998) and OECD (1997).

[8] Although our aim here is not to discuss the differences among the EU countries, some observations are needed regarding the ranking of the EU countries. Evangelista et al (1996, 1997) points out that in large firms more innovation expenditures go on R&D, while in SMEs significantly more go on physical investment. As this pattern holds across most European countries then we would expect that the countries with higher share of SMEs should naturally have much lower share of R&D in innovation costs. Indeed, this may explain the low share of R&D in innovation expenditures of Denmark and Ireland, but cannot fully explain a very low share in Germany.

The share of R&D costs is below the overall EU share in all analysed CEECs, except Slovenia, for which we think that the R&D data are overestimated. Second, the structure of costs without fixed investments produces a picture where the share of some components is difficult to explain. The share of costs of marketing in all CEE countries except Hungary is above the overall EU share. The share of costs for patents, licences and know-how is in all CEE countries above the overall EU share, while in Poland and Hungary is substantially above. A higher share of patents, licences, etc. is consistent to our expectations. However, the structure of R&D and engineering costs is difficult to explain, especially when compared to the EU. Despite the problems in separating R&D from engineering costs, a common feature of the CEECs is the lower share of engineering costs than in the EU. This may be the result of a higher share of costs for patents and licences as well as higher share of physical investment, which reduce the need for own design and engineering or re-engineering activities. However, without disagregated sectoral structure of innovation expenditures, our conclusions remain highly speculative. A higher share of costs for embodied technologies and for patents and licences suggests that there are significant differences with the EU costs structure. Also, the share of R&D costs suggests the different structure of innovation costs. However, difficulties in ensuring comparability between R&D and engineering costs make these conclusions very tentative. Based on the EU data Evangelista et al, (1996) concludes that the mix of innovation inputs, especially R&D and investment, is strongly correlated with firm size, but displays great variations across industries, it also displays little change across countries. So, if we are to search for robust differences in innovation activities based on innovation surveys data, these should be sought at firms and industries levels.

Innovation expenditures from open to closed or isolated economy and vice versa

In section 2, we explained why we have included in the comparison the two Yugoslav surveys which cover the periods 1987-1991 and 1992-96. Here we are interested whether the shift from open to closed (isolated) economy, which Serbian economy witnessed in this period has changed the structure of innovation activities. The data on Yugoslavia show several interesting features in this respect. First, there is a significant decrease in R&D expenditures on the account of increase of expenses for trial production. An economy that is not able to import freely equipment has been forced to increase expenses for its own 'reinventing the wheel' technological development. Second, 'the sanctions wall' has also led to a decrease in expenses for patents and licences as technology is not any more freely available on a market. Third, a slight increase in extramural

R&D may be compatible to the previous two trends, as enterprises which cannot import freely technology from abroad have to try to compensate this by closer contacts with domestic R&D institutes.

The Yugoslav situation represents a reverse process from the liberalisation and the opening of the other CEE countries. In that respect, it may serve as a comparative basis for understanding the changes in innovation activities of the CEECs. By deducing from the Yugoslav case, the shift from closed to open economies in CEE should have led to three trends. First, the decrease in the share of R&D&E expenses as new embodied technologies became available and the need to 'reinvent the wheel' ceases to exist. Second, the opening of the economy leads to an increase in import of foreign technology in the form of physical investments but also in form of patents and licences. Fourth, the ability of enterprises to purchase state-of-the-art technologies from abroad leads to a diminishing role of domestic extra-mural R&D. Finally, in a pure stylised situation we would expect also the increase in expenses for marketing of innovations by companies which in the past did not have significant marketing expenses. Although, we do not have comparative data for different innovation expenditures before and after 1989 for CEECs, an increase in the relative importance of marketing expenses seems the most likely. The shares of physical investments, R&D, and patents and licences do correspond our to predictions derived from the Yugoslav case.

3.4. The Spread of Sectoral Innovation Activities

A full comparison of the spread of innovative activities across sectors between CEECs and EU is still not possible due to differences in industrial classifications. Although, industrial classifications of Slovenia and Poland are harmonised with the EU classification, a full comparison is not possible due to a high level of aggregation of the EU data. Nevertheless, the existing data give us a basis for generating few conclusions or hypotheses. The analysis of the EU innovation surveys showed the variety of sectoral innovation intensities across countries. This diversity is the result of differences in industrial structures, in particular firms size, as well as differences in sources and direction of technical change among sectors but also of different country factors. In table 2, we rank the top five sectors based on shares of innovative enterprises in four CEECs and in the EU. The diversity of national patterns which has been recognised in the case of the EU is also strongly present in the CEECs. Despite differences in industrial classifications table 2 shows that among the top five sectors there is not one common sector among the four CEECs and the EU. A sector which is the most often present is the chemical sector. It belongs to the top five sectors in Slovenia, Poland, Russia and EU, but not in Romania.

Table 2. Top five sectors based on shares of innovative enterprises

SLOVENIA	POLAND II	EU
Electric machinery	Coke, petroleum	Machinery
Radio, TV equipmn.	Chemicals	Electric, electronics
Chemicals incl. pharm.	Electric machinery	Chemicals
Machinery & equipm.	Medical & precision instr.	Transport equipment
Medical & precision instr.	Basic metals	Basic metals

ROMANIA	RUSSIA
Electrotechnics	Non-ferrous metallurgy
Pulp and paper	Oil extracting and refining, gas extracting
Metallurgy	Medical equipment and pharmaceuticals
Prelucrarea titeiului	Chemicals (excluding pharmaceuticals)
Fine mechanics	Microbiological industry

A full comparison of sectoral differences is possible only between Slovenia, Poland and the EU for high tech sectors (chemicals/pharmaceuticals; electrical machinery; instruments; motor vehicles; electronics; other transportation; and computers) (Table 3). Correlation coefficients of shares of innovative enterprises in high tech sectors for Slovenia, Poland and EU are negative between Poland and EU, zero correlated between Slovenia and EU, and with positive correlation (0.65) between Poland and Slovenia. The biggest differences in the shares of innovative enterprises are in the computer sector where the shares for Poland, Slovenia and EU are 14.3%, 23.1% and 72% respectively[9]. We also correlated the sectoral shares of innovative enterprises for Slovenia and Poland for all industrial sectors and the correlation coefficient is rather high (0.78)[10]. This may suggest that the similar sectoral spreads of innovation are linked to similar levels of development. Unfortunately, we do not have comparable data to test this proposition.

[9] Once we eliminate this sector, the correlation coefficients for both Slovenia and Poland with the EU improve to 0.22 and 0.31 respectively.

[10] A comparison is possible only if we exclude recycling and coke petroleum for which in each of the countries there are data for only one of these two sectors.

The available data allow us only to explore the differences in the distribution of relative shares of innovation across sectors.

Table 3. Shares of innovative enterprises. Correlation coefficients between EU, Slovenia and Poland in high tech sectors

	Poland	EU	Slovenia
Poland	1.00		
EU	-0.15	1.00	
Slovenia	0.65	0.00	1.00

We assume that the levels of development play a role in the sectoral distributions of innovations. If so, then less developed countries should have a smaller number of sectors with higher shares of innovative firms while more developed countries should have even more distribution across sectors. If we take into account that the GDP per capita of the CEECs is several times lower than the EU GDP per capita, this proposition seems quite plausible. In order to explore this proposition we ranked all sectors in descending order based on the share of innovative firms. It occured that there are show surprisingly similar distributions of descending shares of innovative firms across sectors. The slope coefficients or rates of change along the line range between -2.33% to -3.64%[11]. When we regress the shares of innovative sectors on descending ranking of sectors, we get very high coefficients of determination which are above 0.95, except for Slovenia (0.84). Also, regression coefficients are highly significant.

Why the distributions of shares of innovative enterprises are so similar? The slopes of the distributions are very similar even though the classifications are different in terms of number of sectors. In the case of CEECs, we would expect the distribution to be much more skewed, i.e. concentrated on only few sectors where these countries have technological advantages. For the EU, we would expect a less skewed distribution indicating more balanced shares of innovative enterprises in different sectors. The result is that the distributions of shares of innovative firms across sectors are very similar when sectors are ranked in descending order while the technological structure of leading sectors is nationally very specific. This suggests that the diversity of national technological advantages is distributed in a very similar fashion but the content

[11] A standard deviation of distributions primarily reflects the number of the sectors or the degree of disagregation. Namely, the correlation coefficient between number of sectors and the difference between sectors with maximum and minimum share is 0.91, and the correlation between standard deviation and the number of sectors is 0.89.

of this diversity is nationally very specific. The national determinants influence the sectoral technological structure, but they do not determine the distribution of shares of innovative firms across sectors. This distribution seems insensitive to country specific conditions and levels of development.

3. 5. Objectives of Innovation

The specificities of an economic environment are shaping innovation not only in terms of its speed but, probably, also in terms of its objectives. The different relative prices, different demand conditions and company strategies should influence the objectives of innovation activities. A specific economic environment of the economies of the CEE, with significant changes in relative prices, in supply and demand conditions as well as changes in ownership incentives, are likely to have effects on the objectives of innovation.

We grouped objectives of innovation from different innovation surveys for the CEECs and the EU. We normalised them on the same 10-1 scale though the differences between objectives based on frequencies and on intensities should be taken into account. A comparison shows that the objectives are much more similar than we would expect given the differences in the economic conditions. There are several elements which are common for the EU and the most of the CEECs.

First, product quality is one of the most important objectives in the EU as well as in the CEECs. The second most often objective in the CEE and the EU is an increase or maintenance of the market share. Extending the product range within the main field is the third most important objective in the EU as well as in the CEECs. This indicates that the enterprises in CEECs do not differ from the enterprises in the EU in terms of the most important objectives of innovation.

Nevertheless, the comparison shows also two interesting differences which support our proposition that differences in the economic environment should have effects on the objectives of innovation. First, the creation of new markets is not important objective for the EU as for the CEE enterprises. This seems logical in view of the previous closeness of the CEE economies as well as in view of demand problems for the CEE enterprises. Second, among the objectives of reducing production costs there are differences in the importance of wages, energy and material costs. In the EU firms the importance of the reduction of the share of wage costs rank very high while in the CEE the reduction of material and energy consumption stands as much more important objective.

The comparison also shows that in both, the CEE and the EU, the objectives of quality, market share and product range are relatively more important than the innovation activities to reduce costs. From this we could hypothesise that in both, the EU and CEE, the dominant type of competition is Schumpeterian (market share, quality) or Smithian (product differentiation) rather than Ricardian type of competition based on prices.

4. Conclusions and Summary

The paper analysed the differences in patterns of technical change among the CEECs as well as between the CEECs and the EU by using the data from several CEE innovation surveys and the CIS. As pointed in section 2, the analysis based on inter-country comparisons of innovation surveys is faced with a serious methodological problems and interpretative shortcomings. Therefore, our conclusions relate not only to understanding of innovation activities in the CEECs,but also to the methodological aspects of innovation surveys as statistical tools.

Given the discussed methodological problems of innovation surveys and the small number of the CEE countries analysed, our conclusions should be considered as highly exploratory rather than conclusive. However, even being of this nature, they improve our understanding of technical change in the CEE.

4.1. Among a great number of findings based on very different degrees of empirical evidence we list below those that seem to be the most important:

- the share of innovative enterprises in the CEECs is at the bottom of the EU league reflecting a limited scale of innovative activities in the CEE countries;
- on the example of Russia we showed that the determinants of innovative activity are extra-mural and intra-mural suggesting that the innovation system in the CEECs is still characterised by a strong role of extra-mural R&D organisations;
- the shares of innovative firms in the CEECs are related to their economic recovery but not to the share of sales based on new innovative products. This suggests that the link between different input and output indicators is a complex one and needs further investigation;

- the shares of innovative enterprises in Poland and Russia are decreasing indicating, probably, a decrease in search efforts which characterised all the CEE economies at the outset of transition;
- the structure of innovation expenditures of the CEECs is different from the EU cost structure in two important respects. The CEECs purchase relatively more embodied technology than the EU; they spend relatively more on patents and licences; and have a lower share of R&D expenditures in total innovation expenditures. However, we were unable to disentangle the full structure of the intangible innovation expenditures.
- the share of enterprises with R&D activities is significantly lower in the CEE than in the EU countries. This is compatible to a low shares of innovative enterprises and the lower share of R&D in innovation costs.
- the patterns of sectoral shares of innovative activities are nationally specific. Differences in industrial classifications do not allow us to make a full analysis of these differences.
- product innovations are somewhat more often than process innovations, but they are also highly correlated to each other. This is opposite to the socialist period where according to Berliner (1976) and Gomulka (1986) product innovation was much less present than process innovation.
- the shares of sales based on innovative products in the CEECs are lower than in the EU, but their levels and changes are not related to growth and restructuring of individual countries. Why this link is not direct at a country level would require further research.
- the main objectives of innovation activities between the CEE and the EU are similar with product quality, market share and extensions of product range being at the top in both cases. Also, objectives related to market share, quality and product differentiation are in both cases ranking much higher than those related to production costs. Differences in objectives seem to be secondary and they are present in the more important role of new markets for the CEECs and of reduction of costs of material and energy rather than wages as in the EU.
- sources of ideas for innovation are rather similar in the CEE and the EU with clients and internal sources as being the most important;
- among the factors which hamper innovation internal factors are the most important in the EU while in the CEECs the external financial and other constraints are the most important

4.2. A comparison with the EU innovation survey shows several important factors of similarity as well as differences. The most important differences come from differences in the development levels. These are differences in:

- the lower share of innovative enterprises, the share of R&D expenditures, and the share of firms with R&D expenditures in the CEE than in the EU;
- higher share of expenditures for embodied technology, patents and licences in the CEE than in the EU;
- nationally specific sectoral differences in innovation intensities;
- the economic system specific differences are in the lesser importance of new markets, energy and material costs as objectives in innovation, and in the differences in the relative weight of internal vs. external factors which hamper innovation.

Similarities in innovation activities between the EU and the CEE come either from features of the innovation process which are present in all market economies, or from convergence in the innovation process of the CEECs in their assimilation of features of market economies. These similarities are in:

- higher innovation intensity of large firms;
- similarly skewed distributions of sectoral innovation intensities;
- the main objectives of innovation activities
- sources of innovative ideas.

4.3. The analysis has generated also several methodological insights which are relevant for further comparative research based on the innovation surveys:

i) the share of enterprises and the structure of innovation expenditures have turned out to be much more robust indicators of national and developmental differences than initially expected.

ii) ensuring the comparability of definitions and the reduction of the subjective nature of responses are essential for further comparative work based on innovation surveys.

iii) a link between the shares of enterprises and shares of sales based on new innovative products, and their link to economic growth and restructuring needs to be explored further through sectoral and national level data.

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