



# Raising Private Sector R&D in the New Member States: Does it help their economies catching up?

Report on a DG JRC-IPTS Workshop held in Seville (Spain), 13<sup>th</sup> – 14<sup>th</sup> December 2007

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The workshop and the corresponding report both have taken stock of a comprehensive study on private sector R&D in the 10 New Member States [NMS] that entered the EU in 2004. This study was conducted by national experts from the NMS, namely by IOANNA GAREFI, TONIA DAMVAKERAKI, EFFIE AMANATIDOU (Cyprus); ZDENEK KUCERA, VLADISLAV CADIL, MIROSLAV JANECEK, JIRI JANOSEK, DANA VACHOVA (Czech Republic), TARMO KALVET, ANNE JÜRGENSON, TÕNIS EERME, ALAR OPPAR, KADRI UKRAINSKI (Estonia); ATTILA HAVAS (Hungary); ALFRED VANAGS (Latvia); MONIKA KRIAUCIONIENE (Lithuania); J.P. SAMMUT (Malta); TADEUSZ BACZKO, JACEK KUCINSKI, ROBERT GARBARCZYK AND MARCIN OSTASZEWSKI (Poland); VLADIMÍR BALÁŽ, ŠTEFAN ZAJAC (Slovakia); SANDRA M. LEITNER (Slovenia). The coordination of the study was in the hands of KLAUS KUBECZKO, K-H. LEITNER and MATTHIAS WEBER, under contract with JRC-IPTS through the European Techno-Economic Policy Support Network [ETEPS]. Valuable support was provided, as part of the JRC Integration and Enlargement Action, by GIANCARLO CARATTI and MILENA RAYKOVSKA.

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## Preface

The workshop on *'The role of private sector R&D in the catching up of the new Member States'* was organized as part of the common activities of the Industrial Research and Innovation Action of the Knowledge for Growth Unit within the DG JRC-IPTS [Institute for Prospective Technological Studies]. Thus, the 'Focus on New Member States' Activity gathers and analyses information and offers key actors a platform to share knowledge and discuss (through regular seminars and workshops) challenges and opportunities in industrial research and innovation in the new Member States. In doing so it also addresses the role of private R&D in 'catching up' in light of the EU's ambition of becoming a competitive knowledge-based economy (with a research intensity approaching 3% of GDP).

The activity aims to fill this gap by studying private R&D patterns and trends at the sectoral level and their relation to policy influences and framework conditions in the new Member States. The research also includes the evaluation and comparison of R&D performance in selected sectors and the identification of good practice in this respect.

A Steering Committee of users from new Member States has been set up to define their needs in this area, and to discuss, use and diffuse the results emerging from this activity. Within the JRC Enlargement and Integration Action, this is one of the four specific projects the IPTS is providing to support the integration of new Member States into the EU (see <http://iri.jrc.es/nms.htm> for further information).

This report represents a synthesis of the work done so far in this Activity. It takes stock of a comprehensive study on state of the art and recent trends in terms of private sector R&D in the NMS (see Annex II: Final Report). For the future it is scheduled to continue with such empirical studies at various – mainly more disaggregated – levels and also to deepen further the analytical approach in order to provide the framework for sound and evidence based policy support.



## Executive Summary

While R&D<sup>1</sup> is concentrated in advanced industrial economies and at favourable locations within the larger countries, the advantages of physical location (proximity) might be diminishing with the increasing speed and globalisation of information flows around the world and with easier access to the knowledge built up through R&D. This raises the question of whether policymakers would more usefully focus on making their country an attractive location for R&D, or promote easy access to, and absorption of, knowledge generated elsewhere. Related to this, the question of how to reap the benefits of R&D output generated by Foreign Direct Investment [FDI], either inward or outward, remains a major challenge. The latter holds in particular for the new Member States [NMS]<sup>2</sup> as – after the former research and innovation capacities were widely abolished during the transition process – currently FDI in these countries seems to be the key in terms of any R&D activities.

In general, the New Member States are still in a process of transition, industrial restructuring and integration into the EU economy. In fact, getting closer to the existing European frontiers in terms of technology, R&D and innovation is quite challenging and, therefore, is supposed to take some time. And the initial gap was evident. In 2003, right before entering the EU, the R&D intensities (Gross Expenditures on R&D [GERD] / Gross Domestic Product [GDP]) in all NMS were significantly below the EU-15 level, the public R&D systems appeared to be rather fragmented, and in terms of the expenditures of Business Enterprises on R&D [BERD] more than a doubling of the pre-accession levels would have been required just to catch up with the EU-15 average. Accordingly, policymakers put emphasis on leveraging the low R&D levels in the NMS in order to support the economic catching up and, by means of that, the integration of the NMS economies into the EU.

Admittedly, the real challenge in this regard is to leverage the private sector R&D activities as this can be influenced by any policy measure only indirectly and reflects rather long-term aspects such as the macro-economic conditions, prosperity, quality of institutional environment, human resources and the science base of a certain country. Accordingly, focusing on corporate R&D appears to be crucial for analysing the NMSs' way towards achieving the objectives of the Lisbon strategy as well as the Barcelona target. The current situation and trajectories of the corresponding public sector R&D activities anticipating a common European Research Area [ERA] should however be taken into account too. Thus, monitoring these developments seems to be of outstanding importance since this may provide an early indication whether Europe is on the right track in terms of NMS integration and catching up to the world technological frontier. Therefore, this will remain to be a matter of interest also in the future.

This report illustrates some recent trend patterns in the NMS concerning R&D intensity, taking the 3% Barcelona target and the EU average as a benchmark. For instance, the absolute R&D intensities in 2005 are related to the corresponding annual changes per country. The image that emerged is heterogeneous. In general, there are large disparities among the EU-15 and the NMS, and the latter throughout can be found below the mean EU-27 R&D intensity.<sup>3</sup> With respect to the 'technological output' of R&D activities, for instance approximated by European Patent Office [EPO] patent applications per capita, the same picture emerges: all NMS are (still) below the EU-27 average (year 2003; EUROSTAT).

Convergence in terms of R&D intensity, if at all, can be recognized only to a limited extent. Indeed, the majority of low R&D-intensive Member States (i.e. R&D intensity below 1.5%; namely all NMS) is

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<sup>1</sup> For a definition of R&D see e.g. UNCTAD: [http://www.unctad.org/en/docs/wir2005ch3\\_en.pdf](http://www.unctad.org/en/docs/wir2005ch3_en.pdf), Box III.1.

<sup>2</sup> NMS: Cyprus (CY), the Czech Republic (CZ), Estonia (EE), Hungary (HU), Latvia (LV), Lithuania (LT), Malta (MT), Poland (PL), the Slovak Republic (SK) and Slovenia (SI).

<sup>3</sup> EU average: 1.84% GERD as % of GDP in year 2005. Thus, among the NMS the highest R&D intensity is reported for the Czech Republic (1.42%) and the lowest (0.39%) for Romania. Data: EUROSTAT, OECD.

catching up with the remainder of the Union, albeit at different speeds. However, there are also some low R&D-intensive Member States (among them four NMS: Bulgaria, Poland, Malta and Slovakia), apparently falling further behind since 2000 (Source: EC (2007): Key Figures, p. 54)<sup>4</sup>.

In general, common patterns in the NMS can be seen in their low R&D intensities as well as in the fact that the government sector (still) accounts for a very large share of the R&D funding.<sup>5</sup> In other words, it seems that the pre-accession situation has not yet changed significantly: R&D sectors and the National Innovation Systems [NIS] appear to be still dominated by the public sector and the overall amount of investments in R&D remains comparably low. Hence, the efforts of the policymakers have not yet yield fruits and it seems that still a long way remains to go for the NMS in order to catch up with the remainder of the EU.

Nevertheless, besides the statistics concerning R&D investments, looking at a number of structural and knowledge economy indicators, some NMS indeed seem to get closer to the position of older Member States. In fact, the picture is diverse: countries ahead in terms of R&D are not always the same as the ones showing fast growth; fast risers on the European innovation scoreboard do not necessarily generate/attract much R&D investment. This suggests, particularly for those NMS facing significantly rising GDP figures, there are a number of determinants – aside the performance of R&D activities – currently triggering the economic growth process in a more substantial way.

However, according to an examination of R&D dynamics at country, sector, and partly company levels<sup>6</sup> there is – at least currently – no common trend pattern uniformly evident in all NMS rather than a wide heterogeneity (at a commonly low amount of R&D activities); and this picture seems to become even more diversified as the focus of analysis shifts towards higher disaggregation (macro → sector → firm-level). Moreover, rising figures in terms of R&D are reported by few sectors only; particularly such sectors as pharmaceuticals or automotive, which are growing in many NMS but have not (yet) become substantial pillars of the national economies. Accordingly, these emerging sectors with dynamic R&D trajectories might be seen more as 'bright spots' than as being the heralds of a common catching up in terms of R&D activities in the NMS.

The fact that aggregated country-level considerations related to sector studies may provide differentiated pictures calls for a complementary analytical focus on firm-level trajectories. In fact, such empirical studies indicated a number of companies in each analysed sector performing R&D quite successfully, setting its pace and its frontiers (even if these frontiers may refer to the production possibility set given the particular environment of a certain NMS only). However, a notable amount of companies lagging behind has been detected too. This implies that the most relevant aspects for the current development in the NMS are supposed to be the individual institutional framework conditions for a certain company and the management capacity and entrepreneurial competence rather than the amount of resources and/or support provided in terms of R&D activities.

In general, evidence suggests that the current growth in the NMS seems to refer mainly to progressing structural changes, some emerging sectors, etc. and to an increasingly efficient allocation of production factors (decreasing inefficiencies) rather than to catching up in terms of R&D performance and getting closer to the technological frontier. With respect to the initially raised policy question this may imply a comparably marginal importance of policymaking in the field of the NMS' R&D capacity building. However, although the latter may currently appear to be only a minor source of economic growth in the NMS, with respect to the mid to long term perspectives of these countries the importance of R&D is supposed to be rising. Thus, R&D may emerge to be one of the main sources of growth given the further integration of the NMS into the EU economy and the correspondingly needed catching up in terms of the technological frontier.

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<sup>4</sup> The source mentioned identified also Slovenia as falling further behind the EU average. However, the data for Slovenia have been revised recently and accordingly Slovenia falls not in this category anymore (see Figure 1, below).

<sup>5</sup> In average in the EU-27, BERD refers to 54.5% of total R&D expenditure. The public sector contributes 34.8%. In most of the NMS this relation is vice-versa!

<sup>6</sup> See JRC Scientific and Technical Report: Private sector R&D in the NMS; forthcoming.

However, for anticipating future developments – and therefore also for current policy making – perhaps even more relevant than searching for convergence in terms of R&D are the relevant determinants and main drivers of the corresponding trajectories in the NMS. With respect to the latter, an empirically based study has identified FDI as quite eminent for the evolution of R&D in the NMS, implying a more or less tight embedding of the R&D investment in the overall R&D strategy of a multinational firm.<sup>7</sup> Thus, due to the internal competition between R&D locations of a Multi-National Corporations [MNC], there is a non-negligible risk that these activities may move elsewhere if the conditions for R&D and/or the overall R&D strategy of the company change. The maintenance of private sector R&D activities by means of FDI thus comes at the price of uncertainty regarding the potential footloose characteristics of such investment. However, in the end, the extent to which R&D might become footloose depends on the attractiveness of a certain location and, accordingly, on the quality and evolution of those factors and conditions due to which R&D-investment were initially set up (and maintained!).<sup>8</sup> This implicitly includes also the risk of a 'race-to-the-bottom' in terms of work-safety, taxation, environmental regulations, etc. between locations competing for attracting and keeping such investment (as far as these factors are indeed representing investment decision criteria and may therefore favour one location over another).

In this regard some individual sector case studies in the NMS<sup>9</sup> have shown that the reasons for foreign investments in R&D can be manifold. Of outstanding importance for any investments in R&D in the NMS seems to be a combination of three factors: (1) the quality of the available human resources, (2) the labour costs, and (3) the access to local markets.

In contrast to these evident key factors, it is difficult to assess the impact of a number of framework conditions supposed to be beneficial for performing R&D, like for example tax incentives. While they certainly matter for specific decisions, a corresponding survey conducted in course of the individual NMS analyses suggested that their importance might be over-estimated. If available, specific incentives are welcome, but the main determinants of investments in R&D apparently lie elsewhere (see key factors above). In fact, although R&D support measures as well as international technology and know-how transfers may bring important knowledge to an economy, that alone certainly is not enough. Using new technologies efficiently requires creating additional absorptive capacity, while a continuous effort has to be made to keep up with technical change. This is particularly true given the fact that wages tend to rise as a country develops, facilitating the entry of lower cost competitors in the market, both currently observable in the NMS.

Given the direct and indirect linkages among all the issues mentioned above (many of them indeed are 'double edged'), there is no clear answer on the initially raised question concerning the appropriate emphasis of policymaking in terms of R&D in the NMS. In fact, how to cope with all this and what does it imply for policy making in the NMS obviously needs to be further studied, thus taking into account the individual characteristics of each NMS, the heterogeneity among them, the persisting vs. the emerging economic structures, and any possible path dependencies. However, there are some cross cutting issues arising as critical for the future and thus requiring particular attention (these points and potential future avenues of research in this regard have been the main subjects of the discussion during the workshop on '*The role of private R&D in the catching up of NMS*', held December 13th-14th 2007 in Seville at the IPTS):

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<sup>7</sup> This development – while being generally perceived as very positive – has a number of double-edged impacts on the evolution of the R&D base in the NMS. On the one hand, foreign investments tend to contribute to the upgrading of the managerial knowledge and organisational competencies as well as diffusion of new technologies. On the other hand, the embedding in a global company's R&D strategy often entails a narrowing of the scope of the R&D performed in the country concerned. This, in turn, has consequences for the spectrum of R&D collaboration with domestic universities and research centres.

<sup>8</sup> In fact, the embedding of R&D might not always be sustainable in the case of FDI. Localised R&D could on the one hand lead to local value added. On the other hand, FDI might skim the cream of high-potential researchers in labs that produce footloose R&D for value added elsewhere in the world. In the NMS there is evidence for both.

<sup>9</sup> See JRC Scientific and Technical Report: Private sector R&D in the NMS; forthcoming.

- In general, improving the innovation climate by structural measures rather than by financial incentives.<sup>10</sup> Rethinking the role of publicly funded innovation infrastructures for attracting and embedding private R&D investment. In fact, policy may – to a certain extent – leverage corporate R&D investment by upgrading the existing innovation infrastructure, i.e. creation of at least partly publicly funded research and research-facilitating organisations (technology transfer centres, competence centres, etc.). In a wider sense, investment in the university system also falls under this category, thus adding the educational and human resource dimension. Hence, a notable improvement of innovation infrastructures (universities, research centres, etc.) is supposed to be key for policymaking in the NMS, not only in order to provide sources of qualified R&D personnel, but also as potential partners for industrial R&D, both pre-conditions for performing R&D and thus for attracting investment in R&D;
- Consideration of the national/sectoral innovation systems ensuring the sustainable embedding of R&D investment in the NMS is crucial too. For instance, several NMS have implemented targeted measures (e.g. tax and investment incentives) in order to attract FDI.<sup>11</sup> But, the individual impact of such targeted policy measures needs to be further analyzed. In fact, although such targeted measures have been quite successful e.g. in raising FDI, it is rather unclear whether these incentives are sufficient to ensure that the related investment will stay and not move elsewhere once the conditions may change. In general, rather than addressing specifically foreign firms, efforts should also strengthen domestic (private) investment in R&D and innovation, e.g. facilitating access to venture capital, supporting spin-offs, etc.
- Bundling of national R&D capacities (e.g. through national technology platforms) and seeking a better coordination with European initiatives. For instance, as a co-ordination measure, building of sector or technology-specific platforms is about to be implemented in some NMS (e.g. in Poland). There are potential benefits to be reaped by these measures, e.g. in terms of international visibility, economies of scale, and influence on the agenda-setting at European level. But, suitable approaches for implementing these platforms still have to be developed.
- Emphasising increasingly the role of services, either as stand-alone research-intensive activities (e.g. Knowledge Intensive Business Services [KIBS]) or as services supporting R&D performed in other sectors (e.g. standardisation, IT services);

Summarizing these points from a policy perspective: Given the distance of the NMS to the technological frontier and also the gap in terms of R&D intensity (Barcelona target) compared to the remainder of the EU, emphasis might currently be more usefully on promoting easy access to, and absorption of, knowledge generated elsewhere accompanied with a sophisticated master plan for improving the existing R&D and innovation capacities systematically. In fact, making the NMS an attractive location for R&D appears to be a straightforward policy objective, but any corresponding measure should be embedded in an overall improvement of the institutional/environmental framework conditions in order to ensure sustainable investments in R&D in the NMS.

From a techno-economic point of view, in general, further and more detailed analyses seem to be needed focusing on NMS individually, their key economic sectors and/or companies in order to substantiate the general impression arisen from the background study and the workshop. This may provide the base for a better understanding of the ongoing processes and also for sound policy support accordingly. In particular, studies are needed that fill the gap between the available empirical evidence from macro-level analyses and the anecdotal evidence from firm level case studies in the NMS. This is currently a matter of interest in a number of ongoing projects (e.g. analysing corporate R&D at firm level in different sectors comprising distinctive R&D intensities<sup>12</sup>) taking into account firm size patterns (e.g. SMEs), R&D environmental issues at certain regional levels,<sup>13</sup> etc. Thus, it should be analysed what implications may have the above mentioned pitfalls and drawbacks in relation with the outlined favourable framework conditions for R&D in the NMS in a mid to a long term perspective.

<sup>10</sup> This concerns, for instance, the strengthening of the relationships between private as well as public innovation actors. In fact, there are already some examples of private firms getting engaged in funding R&D centres or university institutes in the NMS.

<sup>11</sup> Thus, the major objective in most of the cases is not increasing the overall investment in R&D!

<sup>12</sup> See Sector Study: Framework Service Contract 150083-2005-02-BE; EC (2006c)

<sup>13</sup> See ERAWATCH project: <http://cordis.europa.eu/erawatch>.

Furthermore, the participants of the workshop also outlined the importance of studying potential cut-off points of the structural funds applying suitable simulation/modelling techniques and taking stock of the experiences made elsewhere in the EU in this regard (Spain, Portugal, Greece, etc.). Crucial questions concern the cut-off levels, cut-off timing, and any post-cut-off adjustments. Blank spots were also seen with respect to the consideration of the individual domestic markets in the NMS (entrepreneurial spirit, type of products/sectors, etc.), the role of macroeconomic stability as well as the particular framework conditions, and the development of comprehensive labour markets for researchers in NMS (wages, career possibilities, migration studies, mobility of workers, etc.). Analytically, the experts proposed a distinction of foreign vs. domestic R&D when considering R&D in NMS and, moreover, called for working out the particular differences of FP6 / FP7 programmes with respect to R&D in the NMS.

Going ahead in terms of the above outlined avenues of research in the field certainly may help getting a clearer picture of R&D in the NMS.



# Raising private sector R&D in the New Member States: Does it help their economies catching up?

## 1 Introduction

The new Member States [NMS]<sup>14</sup> are in a process of transition, industrial restructuring and integration into the EU economy, which still has a long way to go. Nevertheless, on a number of structural and knowledge economy indicators, some countries are close to or even superseding the position of older Member States. The picture is diverse: countries ahead on R&D are not always the same as the ones showing fast growth; fast risers on the European innovation scoreboard do not necessarily generate/attract much R&D investment by companies. The overview provided by this report is a synthesis of the final project report of the ETEPS study 'Private Sector R&D in the NMS' (Specific Contract No. C150083.X7), updated with further corresponding material. Thus, the study seeks to analyze the situation of private sector R&D in the new Member States by comparing the available statistics. It also investigates the presence of these countries in key sectors relying on R&D, with a focus on company cases where sector data are missing or outdated.<sup>15</sup>

The Member States are implementing "Lisbon Programmes" (almost all have set individual targets for R&D investment) in order to cope with the challenge of generating higher growth and employment. They strengthen the political accountability and allow for the assessment of the reform measures taken at country, region and/or sector level. For instance, the Czech Republic has released a (three-year) National Reform Programme, representing an integrated and cohesive approach and targeting macroeconomic, microeconomic and employment policies, which can be revised in case of political changes and which has been elaborated on the basis of the Integrated Guidelines for Growth and Jobs (2005–2008), adopted by the European Council in June 2005.

According to the final project report on Private Sector R&D in NMS (see Annex II) a number of cross-cutting issues for policymaking on R&D and innovation can be identified:

- Consideration of national and sectoral innovation systems to ensure the embedding of R&D;
- Future development of the human resources base as a pre-condition for performing R&D and thus for attracting investment in R&D;
- Continuous improvement of innovation infrastructures (universities, research centres, etc.), not only as sources of qualified R&D personnel, but also as potential partners for industrial R&D;
- Emphasising increasingly the role of services, either as stand-alone research-intensive activities (e.g. KIBS) or as services supporting R&D performed in other sectors (e.g. standardisation, IT services);
- Improving the innovation climate by structural measures rather than by financial incentives;<sup>16</sup>
- Bundling of national R&D capacities (e.g. through national technology platforms) and seeking a better coordination with European initiatives.

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<sup>14</sup> NMS: Cyprus (CY), the Czech Republic (CZ), Estonia (EE), Hungary (HU), Latvia (LV), Lithuania (LT), Malta (MT), Poland (PL), the Slovak Republic (SK) and Slovenia (SI).

<sup>15</sup> This is consistent with recent trends in research and innovation policy research stressing the integration of RTDI-policies into stronger industrial or sectoral policies (Malerba 2004).

<sup>16</sup> This concerns, for instance, the strengthening of the relationships between private as well as public innovation actors. In fact, there are already some examples of private firms getting engaged in funding R&D centres or university institutes.

Furthermore, from a policy perspective, there are a number of issues too that would require further investigation in order to be able to better assess the role and the impact of different types of policy measures in the new Member States:

- The impact of targeted policy measures in terms of attracting and embedding foreign R&D investments. In fact, several NMS have implemented such targeted measures (e.g. tax and investment incentives). Thus, the major objective is increasing investment in R&D. But, although targeted measures have been quite successful in raising FDI, it is rather unclear whether these incentives are sufficient to ensure that this investment will stay and not move elsewhere once the conditions may change. In other words, the key question concerns the sustainable embedding of corporate R&D investment in the NMS innovation systems.
- The impact of targeted measures on leveraging R&D funding: Rather than addressing specifically foreign firms, efforts should also stimulate domestic (private) investment in R&D and innovation, e.g. facilitating access to venture capital, supporting spin-offs, etc.
- The role of publicly funded innovation infrastructures for attracting and embedding private R&D investment: Policy may – to a certain extent – leverage corporate R&D investment by upgrading the existing innovation infrastructure, i.e. creation of at least partly publicly funded research and research-facilitating organisations (technology transfer centres, competence centres, etc.). In a wider sense, investments in the HES also fall under this category, thus adding the educational and human resource dimension.
- The role of national platforms and clusters: As a co-ordination measure, building of sector or technology-specific platforms is about to be implemented in some NMS (e.g. in Poland). There are potential benefits to be reaped by these measures, for instance in terms of international visibility, economies of scale, and influence on the agenda-setting at European level. But, suitable approaches for implementing these platforms still have to be developed.

## 2 Bridging technological gaps and moving frontiers: Impetus R&D

Closing any gap – namely realising convergence – in terms of R&D, technology, innovativeness or any other indicator implies achieving growth rates exceeding those of the corresponding leader who currently makes the pace and provides the benchmark accordingly. But, currently technology is advancing faster than ever which makes the benchmark – the technology frontier – permanently moving outwards, expanding the production possibility set.<sup>17</sup> This is captured in the economic literature in comprehensive parametric or non-parametric models estimating the relevant isoquants and their changes in terms of shape or slope in time. In this study, we take a modest first step by investigating the R&D trajectories of the EU-25 countries trying to answer the question whether there is indeed empirical evidence of convergence in terms of R&D efforts and whether this is, however, a sign of economic and technological catching up.

Assessing R&D growth rates and the trajectories in the NMS: What is the appropriate benchmark?

No doubt, catching up with the global technological frontiers is a common target, also for NMS. But, considering the need of convergence and integration of NMS economies into the EU, benchmarking NMS and the EU-15 for the time being appears to be more appropriate. Hence, for this study the emphasis is on the latter. Nevertheless, it needs to be mentioned that the overall performance of R&D in Europe in recent years was lacking behind the development of the most relevant competitors (US, Japan, China, ...). After evidence of slowly catching up, Europe as a whole again seems to fall further behind in terms of technology, approximated by R&D intensity.<sup>18</sup> In this regard, Phillippe Aghion (2006) argues that R&D intensity systematically increases as industries are getting closer to the technological frontier and, since the EU-15 countries have moved closer to the world technological

<sup>17</sup> In this context, the concept of technological frontiers refers to the efficient boundaries of the production possibility set (comprising all production possibilities technologically feasible), moved in- or outwards by technological change. See in this context e.g.: Solow (1957, p. 312), based on Cobb und Douglas (1928); Shepard (1953); Carlson (1939); Cassels (1936); Allen (1938) or also e.g. Chambers (1988) and Varian (1992).

<sup>18</sup> See e.g. European Commission (2006a and 2007a) for a general overview, and with particular respect to corporate R&D: European Commission (2006b): Analysis of the 2006 EU Industrial R&D investment Scoreboard.

frontier as an effect of a long period of catching up, they should invest even more in R&D. Moreover, within the EU, the most advanced countries should invest proportionally more since they benefit from a higher productivity of R&D. Thus, divergence between leading and lagging European countries might be explained.

What about returns to scale in terms of R&D as a primer to innovation and growth?

Certainly there is a positive marginal effect of R&D in case of the high-tech performers, and, as known from developing countries, a certain minimum capability is needed in order to achieve any positive returns to R&D investments at the lower end of the scale. Indeed, in low R&D intensive countries, initially government-funded R&D might be more important than business-funded R&D as it is critical for creating and developing Science and Technology [S&T] capabilities (a prerequisite for catching up with countries at the technology frontier) and for supporting research projects with expected high social benefits, which the private sector may not find sufficiently attractive. Hence, while investigating corporate R&D investments in the NMS one should also keep an eye on the public side.

Why considering R&D and not other approximations of innovativeness, technological capability, etc.?

In general, countries that failed to build capabilities enabling them to participate in the evolving global networks of knowledge creation risk falling further behind in terms of competitiveness as well as economic and social development.<sup>19</sup> However, any leading position in terms of technology is supposed to be a result of accumulating know-how, performing R&D, creativity and the ability to transform the results into marketable products. There is no magic concerning the leadership, much of it reflects path dependence (the history of any economic system matters!).<sup>20</sup> Outperforming of the frontier performers is only possible if sufficient and adequate efforts are made. In terms of the latter, investment in R&D appear to be the key<sup>21</sup> and, therefore, the centre of the attention here.

### 3 Reflection on R&D in the NMS before and after accession

The transition from formerly planned to market economies in most of the NMS went hand in hand with significant structural changes. Accordingly, also the corresponding National Systems of Innovation [NIS]<sup>22</sup> and the type of R&D, public as well as private, have changed considerably. In view of the challenge of integrating the NMS economies into the EU, this process of structural adjustment and evolution is likely to take some time. Hence, our search for evidence of converging R&D patterns in Europe is cast of a general reflection of what we know about the NMS in the pre-accession situation and what we expect to see happen there after EU accession?

In the period right before accession, the amount of R&D performed was low. Nevertheless, it has to be mentioned that in some countries and in particular fields of science, noteworthy results were achieved, that proved to be competitive also at a global level.

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<sup>19</sup> See: UNCTAD (2005), chapter III: Innovation, R&D & Development ([http://www.unctad.org/en/docs/wir2005ch3\\_en.pdf](http://www.unctad.org/en/docs/wir2005ch3_en.pdf)).

<sup>20</sup> As, on the one hand, accumulating knowledge and capabilities are core for achieving technological competence and, on the other, technological breakthroughs could make some knowledge and achievements obsolete there is always a certain path dependence apparent in setting the frontier or getting closer to it.

<sup>21</sup> In fact, empirical studies suggest a direct relationship between R&D and growth. For instance, Guellec and van Pottelsberghe (2004) found the long-term impacts on economic growth of public R&D and business R&D to be strong and significant. Business R&D undertaken in other countries apparently also plays an important role. Moreover, increased domestic business R&D accentuates the positive impact of both public and foreign business R&D. In other words, business R&D (either domestic or foreign-funded) has both a direct impact on a country's economic growth as well as an indirect one through improved absorption of the results of public R&D and R&D performed in other countries.

<sup>22</sup> Enterprises are the principal agents of innovation today, but they do not innovate and learn in isolation. They rely on intricate (formal and informal) links with other firms and with public research institutions, universities and other knowledge creating bodies like standards and metrology institutes. In undertaking innovation, they react to government policies on trade, competition, investment and innovation. They seek human resources for innovation from the education and training system, and they draw upon the financial system for funding innovative efforts. The complex web within which innovation occurs is commonly referred to as the "national innovation system" or NIS (Nelson 1993, Lundvall 1992)

The pre-accession situation in terms of R&D in the formerly planned economies can be characterized as follows: *R* and *D* were performed separately and all in all not very well connected. *Research* was performed mainly in public institutions and the (mostly state owned) companies dominantly focused on '*development*'. The lack of an integrated NIS with R&D performing private companies as the driving force of developing marketable products significantly hampered a full exploitation of the public research base. Although some NMS had a good reputation in science (more in basic than in applied research), these countries were not considered to be at the technology frontier and were competitive only in terms of niche markets/products.

What about expectations with respect to the transition process and in terms of the EU accession?

In fact, there are number of reasons why NMS could have faced significantly rising corporate R&D investments already before entering the EU. The main argument is rooted in the existence of developed public research systems and qualified human capital, together with emerging businesses. These prospects were further enhanced by the inflow of Foreign Direct Investment [FDI], the improvement of institutional conditions and local infrastructure as well as a rising domestic demand in response to the increase in per capita income.

However, there are some counter-arguments...

Any substantial change provides winners and losers. With respect to the Central and Eastern European (CEE) NMS there is evidence that some companies benefited from increasingly stable macro-economic circumstances. The initial undervaluation of the exchange rate enabled them to re-orient their exports from collapsing Eastern markets to Western ones. In contrast, the diversification of the NMS industrial composition, the corresponding network cut offs and the devaluation of accumulated technological knowledge and capabilities negatively affected their R&D and innovation capacities. Furthermore, the predominantly rapid and extensive way of privatization of significantly undercapitalized companies brought about that larger (usually low tech) enterprises, like metallurgy, heavy machinery, coal mining, energy production, etc. could better face the constraints determined by economic reform than the middle and high-tech manufacturing.<sup>23</sup> The total amount of corporate R&D dropped accordingly. For instance, in Czech Republic corporate R&D decreased by more than half in total – in some branches even more – and the profile of individual R&D units has shifted in favour of non-research activities. Right after the cutback, corporate R&D tended to remain low and the research infrastructure was adjusted to match the available knowledge and remaining science capacities.

Also in terms of publicly financed R&D, the figures decreased (mainly affecting basic research) due to budget cuts during the transition process as well as the closure of R&D divisions of formerly state-owned companies (mainly affecting applied research). The privatization process has triggered as well as hampered the R&D development in the CEE countries and public sector R&D capabilities tended to be diminishing in the pre-accession period which has further weakened the NIS. Hence, rising R&D trajectories are not as obvious as initially suggested and improving the R&D performance of entire economies indeed does not appear to be easy; also not in an environment of up-swinging economies like the NMS.

#### **4 R&D intensity in the NMS: Some empirical evidence**

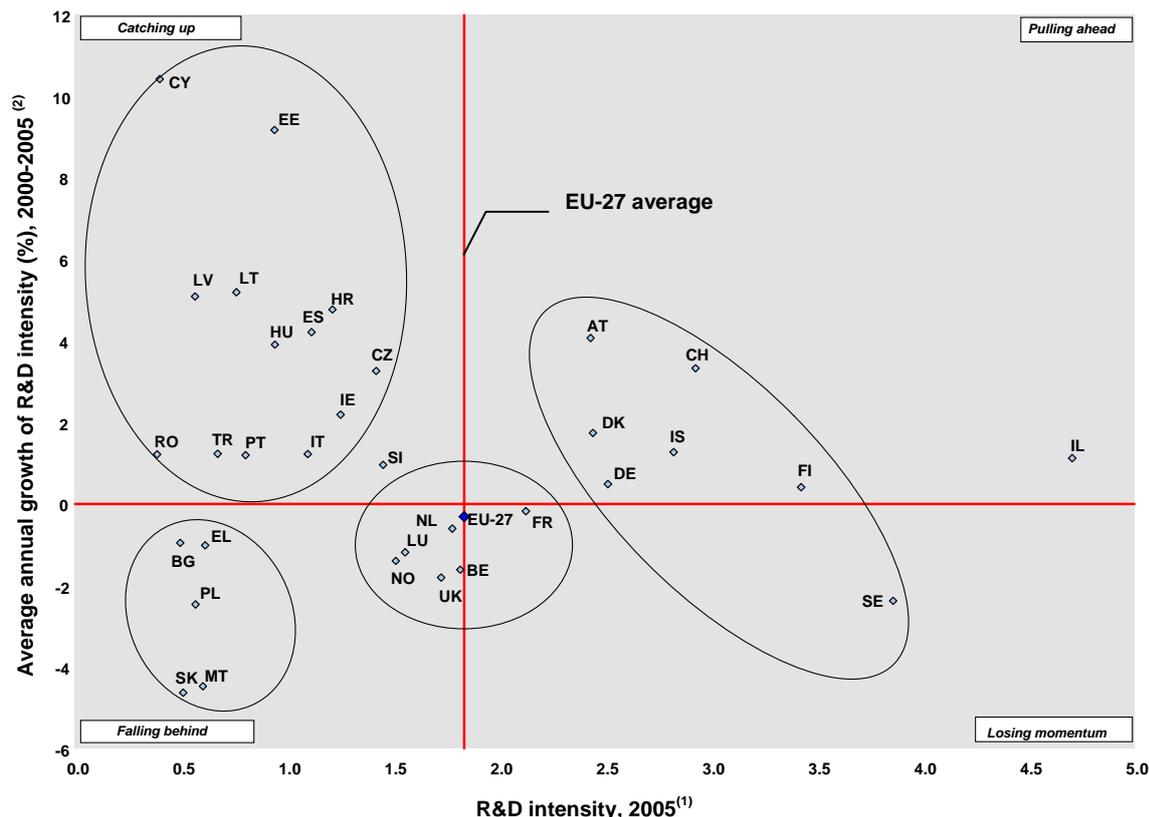
Figure 1 shows the absolute R&D intensity in 2005, the corresponding change between 2000 and 2005, as well as the main (%) sources of funds for R&D expenditures by country in 2005. The picture provided is heterogeneous. In general, there are large disparities within the EU-15 and the NMS-12. The latter throughout can be found below the mean EU-27 R&D intensity (1.84% GERD as % of GDP, year 2005); with Czech Republic the highest (1.42%) and 0.39% in Romania.<sup>24</sup> Concerning the 'technological output' of R&D activities, for instance approximated by EPO patent applications per capita, the same picture emerges: all NMS are below the EU-27 average (year 2003; EUROSTAT).

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<sup>23</sup> Middle-tech manufacturing used certain advantages of foreign capital and technology inflow as e.g. in the case of automotive production: SKODA/VW in Czech Republic.

<sup>24</sup> Data: EUROSTAT, OECD.

Figure 1: R&D intensity, 2005 and average annual growth, 2000-2005



Source DG Research (*Key Figures on R&D 2007*, p. 60; revised data for Slovenia); Data EUROSTAT, OECD

Notes (1) IT, NL, RO, UK, HR, TR, IS, CH: 2004; AT, FI: 2006.

(2) IT, NL, RO, UK, TR, IS, CH: 2000-2004; AT, FI: 2000-2006; EL, SE, NO: 2001-2005; HR: 2002-2004; MT: 2004-2005.

Figure 1 illustrates that the MS can be clustered as catching up, falling further behind, loosing momentum, and pulling further ahead. The NMS can be found in different clusters, meaning that there is no common pattern in terms of R&D trajectories aside from the fact that in all NMS the R&D intensity is low and that the government sector still accounts for a very large share of the entire R&D funding. In other words, it seems that the pre-accession situation has not yet changed significantly: R&D sectors and the NIS are dominated by the state sector.

Further and more detailed analyses seem to be needed focusing on NMS individually and/or their key economic sectors in order to substantiate this first impression. A first investigation of the empirical evidence shows that the declining R&D intensity primarily resulted from reduced funding (particularly in Bulgaria and to a lesser extent in Poland), and in a few cases (Slovakia as an example) from a weakened contribution from the private sector. Table 1 below summarises these tendencies as stylised facts.

## 5 Convergence vs. divergence in terms of R&D: Stylised Facts

Convergence in terms of R&D intensity, if at all, can be recognised only to a limited extent. Indeed, the majority of low R&D-intensive MS (i.e. R&D intensity below 1.5%; namely all NMS) is catching up with the remainder of the Union, albeit at different speeds. However, as indicated above, there are also some low R&D-intensive MS (among them four NMS: Bulgaria, Poland, Malta and Slovakia), apparently falling further behind since 2000 (Source: EC (2007): *Key Figures*, p. 54. Note: revised EUROSTAT data considered for Slovenia). Table 1 summarises these R&D trend patterns.<sup>25</sup>

<sup>25</sup> The stylized trend patterns outlined hereinafter are derived from figures provided by EUROSTAT, DG Research, OECD as well as various statistical sources from the NMS according to the country studies on R&D in the NMS (EC (2006c)). A data availability matrix concerning relevant R&D figures in the NMS has been developed as part of the mentioned study, crossing data from various sources, like data from country's statistical offices, ministry information, and

**Table 1: Trend patterns of GERD and BERD - Convergence in the EU?**

Country	GERD (as % of GDP)		BERD (as % of GDP)	
	<i>NMS vs. EU-27</i>		<i>public expenditures<sup>1</sup></i>	<i>business expenditures<sup>2</sup></i>
	R&D intensity		average annual growth	average annual growth
	tendency 2000 – 2005	2000 – 2005	2000 – 2005	2000 – 2005
Czech Republic	catching up	catching up	catching up	catching up
Slovakia	falling further behind	catching up	falling further behind	falling further behind
Slovenia	catching up	...? <sup>3)</sup>	catching up	catching up
Poland	falling further behind	falling further behind	falling further behind	falling further behind
Hungary	catching up	catching up	catching up	catching up
Latvia	catching up	catching up	catching up	catching up
Estonia	catching up	catching up	catching up	catching up
Lithuania	catching up	catching up	catching up	catching up (if 2006 is considered too)
Cyprus	catching up	catching up	catching up	catching up
Malta	falling further behind	...	...	... (falling further behind)
Bulgaria	falling further behind	falling further behind	falling further behind	falling further behind (little change)
Romania	catching up	catching up	falling further behind	falling further behind

Note: 1) Estonia, Cyprus, Romania 200-2004, no (reliable) data for Malta  
 2) Romania 2000-2004, Malta 2004-2005  
 3) Decreasing until 2004, increasing thereafter (2005, 2006). No clear trend patterns.

Source: EUROSTAT, DG Research, OECD, complemented with data from EC (2006c) country studies.<sup>26</sup>

Splitting up GERD [Gross Expenditure on R&D] into financed by government and business sector suggests that the dynamics of BERD [Business Expenditure on R&D] determine the overall trend patterns. In fact, with the exception of Romania, those NMS that show convergence in terms of BERD as % of GDP also converge with respect to the average EU-27 R&D intensity. In other words: private sector R&D appears to be the key for catching up in terms of R&D figures in the NMS and this, as stated above, can be affected by policymaking only indirectly which gives reason to scrutinize the evidence more deeply.

## 6 BERD in NMS: Evidence from sector studies

Equivalent to GERD, there are also large disparities in terms of BERD among the EU countries. The contribution from private sector to the financing of R&D, in 2005, has been 54.5% of total R&D expenditures in the EU-27, whereas public funds accounted for about one-third of the total R&D spending.<sup>27</sup> However, in most of the NMS this relation is vice-versa, meaning public sector spending on R&D is significantly larger than private sector'. In 2005, even more than 60% of the R&D in Poland, Bulgaria, Lithuania and Cyprus was funded by the government sector.<sup>28</sup>

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publicly available information from analytical sector and/or company case studies, and – in some case – from company interviews too (e.g. Czech Republic).

<sup>26</sup> Concerning data availability and reliability, in general, significant improvements can be recognized in the recent years. Nevertheless, for some countries/years it is still difficult to find reliable and sufficiently detailed data on R&D performance and investments. The latter is particularly lacking in small countries at sectoral level, like e.g. Malta, since sometimes a certain sector consists out of a few companies only and, therefore, data are not made publicly available due to potential confidentiality issues.

<sup>27</sup> 8.5% of total R&D expenditure was funded from abroad (both from private and public sources).

<sup>28</sup> It should be borne in mind that the shares of domestic R&D expenditure financed from private and public sources contain a certain margin of error, due to the unavailability of a breakdown in the category 'funded from abroad' between private ('abroad-private') and public ('abroad-public') sources. At EU-27 level, funding from abroad represents 8.5% of total R&D expenditure (in 2005). Since it can be assumed that an important part thereof comes

However, considering R&D in the business enterprise sector in the EU-27, empirical evidence suggests that BERD growth is driven by few key sectors only.<sup>29</sup> Hence, a selection of such sectors was made and the corresponding sectors have been analysed more in detail. Table 2 provides an overview of the selected sectors per country (see EC (2006c): Synthesis Report, pp. 18-51 for an individual consideration of corporate R&D in each of the NMS and the corresponding reasoning of the particular selection of sectors to be analysed accordingly).

Evidently, the sectors considered as key for the NMS economies differ to some extent from country to country, reflecting the particular characteristics of the industrial structure and the corresponding dynamics (emerging sectors) of each NMS. Differences in this regard are not surprising in the light of an increasing international division of labour and further specialisation in course of the globalisation. Though, this makes deriving stylised facts in terms of business R&D in the NMS a none-trivial task as each sector follows individual dynamics and is affected by its particular global business cycle. Hence, exemplary for all sectors investigated, hereinafter Automotive & Parts (NACE 34...) and the Pharmaceutical Industries (NACE 24.4) will be discussed in brief as they are economically important either for many NMS and/or appear to be particularly emerging with or without long country-specific tradition in the particular sector (relevant for capturing structural changes in the NMS).<sup>30</sup>

**Table 2: Country – Sector Study – Matrix**

Manufacture of...	NACE	Czech									
		Republic	Slovakia	Slovenia	Poland	Hungary	Latvia	Estonia	Lithuania	Cyprus	Malta
Food & Beverages	15							x	x		x
Textiles	17						x				
Publishing & Printing...	22										x
Chemicals & chem. Products (incl. Pharma)	24...	x	x	x	x	x	x		x	x	
Rubber & Plastics	25	x	x								
Base Metals & Fabricated Metal Products	28		27-28				x				
Machinery & Equipment	29			x	x			27-29	x	x	x
Electrical Machinery	31...	x		x		x					
Medical Precision & optical Instruments	33			x		x			x		
Motor Vehicles, Trailers,...	34...	x	x		x	x					
Other Transport Equipment	35...				x						
Furniture & Recycling	36, 37							x			
# Construction	45									x	
# Financial Services	65-67							x		x	x
# Other Business Services	74						x				

Source: EC (2006c), Private Sector R&D in the NMS; individual Country & Sector Studies and Synthesis Report.

### 6.1 Sector Study I: Motor vehicles and related industries

Although the automotive sector is considered as a key industry in many NMS there is quite a difference in terms of absolute importance, particular sector composition and individual specialisation (cluster appearance).<sup>31</sup> In total, the automotive sector in 2004 contributed about 2 bn. EUR or 2.7% to

from private sources (from abroad), it is very likely that the share of the private sector in the financing of domestic R&D is in reality significantly higher than 54.5% (EC: Key Figures, 2007b, p. 55ff.).

<sup>29</sup> EC (2007b), Key figures, p. 58 ff (cited according to p. 62).

<sup>30</sup> See the individual sector studies (Annex II) for further results.

<sup>31</sup> As a very wide range of products are used to assemble a motor vehicle and practically all industrial sectors supply the automotive industry, beside NACE 34 sector, manufacture of electrical equipment for engines and vehicles (NACE 31.61) and manufacturing of rubber and plastic parts (NACE 25) are considered for this analysis too.

the Czech GDP (representing 13% of manufacturing industry GDP and employing 7% of the total workforce). In Slovakia, in 2004, the sector generated 2.2% of the GDP (expected to increase further in future)<sup>32</sup>, in Poland 1.5%, and 1.3% in Hungary. According to ILO [2005], the automotive cluster currently comprises of about 260 suppliers and subcontractors in Slovakia, employing > 25 thousand people, and even 345 producers in Poland with 92.5 thousand employees.<sup>33</sup> In the Czech Republic, the cluster (employing more than 80 thousand people), however, is more concentrated and mainly dominated by Volkswagen / Skoda and its suppliers. In fact, most of the companies in the NMS are managed by strong foreign owners or depend on foreign (tier 1) suppliers.

In general, the overall organisational pattern of the industry, a hierarchically three tier structure, has significant impacts on the corresponding sector characteristics in the NMS. Typically, a number of foreign-owned T1 suppliers have set up plants in the NMS, either via green-field investments or by taking over domestic firms. Most of the domestic companies are T2 and T3 suppliers (with some exceptions) and usually rely on numerous small and medium-sized enterprises, producing basically simple, labour-intensive products given their wage and flexibility advantages compared to larger/foreign firms.

Generally, the automotive sector has (re-)emerged in the NMS quite rapidly. Car producers as well as suppliers – mainly from abroad – have invested significantly. Thus, the main arguments for investing in this sector have been the cost advantages vis-à-vis the EU-15 and the emerging opportunities of getting a foot into the enlarged European market. The first argument holds equally for all investors; the second is mainly relevant for manufacturers from Asia. However, Foreign Direct Investments [FDI] are the main driver of the sector expansion. Investments are either secured by take-over of existing firms or in some cases by joint ventures, being either brown-field or green-field types of investments.<sup>34</sup> Evidence suggests that particularly Asian car companies, engaged in the NMS, can draw upon their domestic networks of suppliers only to a limited extent (given geographical distance or, as in the case of Slovakia, since they are hindered to do so by national interest groups). Hence, suppliers in the NMS emerged and/or are expanding accordingly.

Doubtless, FDI investment played also an important role in terms of R&D as new technologies and processes were brought to the NMS, making the sector productivity rising in most countries which can be mainly explained by intra-firm knowledge transfer. Moreover, for example in Poland, new R&D centres have been installed financed from abroad (like the ones by Delphi and TRW) that led to an increase in sector R&D personnel of more than one third from 2002 to 2004. In contrast, the absolute level of R&D personnel in NACE 34 stayed more or less stable in the Czech Republic and in Hungary (for Slovakia no data are available due to confidentiality restrictions). Indeed, for instance in the Czech Republic – due to the investment by VW – the number of R&D employees increased from approx. 600 in 1991 to 1420 in 2005. But, many other domestic companies either had to close down or to restrict considerably their R&D activities in course of the privatisation what, in total, has led to the stagnating figures in terms of the R&D personnel. If R&D activities are approximated by corresponding expenditures, as done above in aggregated terms, again a slightly distinguished picture emerges. In all considered NMS the investments in R&D have been significantly increasing. Table 3 illustrates the R&D intensities of automotive (and related) industries as well as the corresponding changes in terms of R&D investments per sector.

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<sup>32</sup> In 2003 and early 2004 both PSA Peugeot Citroen and Hyundai-Kia announced their plans to build large final assembly plants in Slovakia. This investment will nearly triple automotive output by the end of the decade and remains the key driver of the Slovak economy. These developments may as well lead to an increase in R&D intensity in the future.

<sup>33</sup> Main producers of passenger cars/vans in Poland are Fiat Auto Poland S.A. in Bielsko-Biala, FSO S.A. in Warsaw, Opel Polska in Gliwice Sp. z o.o., Volkswagen Poznan Sp. z o.o. in Poznan and Intrall in Lublin. Trucks, buses and coaches are produced by MAN Star Truck Sp. z o.o. in Starachowice, Zak ady Samochodowe JELCZ S.A. in Jelcz-Laskowice, Autosan S.A. in Sanok, Solaris Bus & Coach Sp. z o.o. w Bolechowie, Solbus Sp. z o.o. w Solcu Kujawskim, MAN Pojazdy U ytkowe Polska Sp. z o.o. in Poznan, Volvo Poland Sp. z o.o. in Wroclaw and Scania-Kapena Sp. z o.o. in S upsk. Delphi and TRW are the two first enterprises in the sector setting up their own R&D units in Poland.

<sup>34</sup> Important FDI projects have been for instance in the Czech Republic the acquisition of Skoda by VW, while in Hungary Suzuki, General Motors and Audi established their operations by green-field investments. Fiat and Daewoo took over Polish firms and General Motors set up a green-field investment in Poland. PSA Peugeot Citroen and Hyundai Kia are setting up Greenfield investments in Slovakia.

**Table 3: Sectoral R&D intensity, GDP share and investment dynamics**

			<i>Sectoral R&amp;D intensity</i>	<i>Change of R&amp;D intensity</i>	<i>Sector as % of national GDP</i>
	<b>NACE</b>	<b>Sector (manufacture of...)</b>	sectoral R&D as % of sector GDP 2003 or 2004	Ø annual change 2003 or 2004	2003 or 2004
<b>Czech Republic</b>	34	Motor vehicles, trailers, ...	8.8%	5% (2001-2004) about stagnating?	2.7%
	31	Electric machinery & apparatus	1.8%	104% (2001-2004)	1.8%
	25	Rubber & plastic products	0.9%	91% (2001-2004)	1.6%
<b>Hungary</b>	34.4	Parts & accessories for motor vehicles & their engines	2.8%	114% (2001-2003)	0.8%
	31	Electrical machinery & apparatus	3.5%	54% (2001-2004)	0.3%
<b>Poland</b>	34	Motor vehicles, trailers, ...	1.3%	55% (2003-2004)	1.3%
<b>Slovakia</b>	34	Motor vehicles, trailers, ...	1.7%	...	2.2%
	25	Rubber & plastic products	1.1%	10% (1998-2004)	1.0%

Source: EC (2006c), Private Sector R&D in the NMS; individual Country & Sector Studies and Synthesis Report.

Apparently, the sectoral R&D intensities differ significantly from country to country, being the highest in the Czech Republic where the sector also has the highest GDP share. In all other NMS the R&D intensity is lower, but significantly rising, which is supposed to affect likewise the sector share in GDP.

In general, although there are obviously some country-specific paths due to individual historical determinants, different privatisation strategies, etc., which, to some extent, are still perceivable in the structures of the sector,<sup>35</sup> the following can be summarized as common for all: The trend figures of the automotive sector in the NMS over the last years have shown an upswing, constant or rising sector contributions to the national GDPs and increasing R&D intensities, exceeding the country-average levels in manufacturing industries in some cases even by far. These very positive sector trend patterns provide a contrast to the aggregated figures on R&D in NMS as discussed above. Indeed, looking at the R&D expenditure in the automotive sector country wise, it appears to be above the corresponding industrial average, meaning the sector is comparably R&D intensive<sup>36</sup> (note: all NMS have been found to be low-R&D intensive in aggregated terms, see above). However, taking again the example Poland, the relation between sectoral R&D expenditures and total sales has reached only 0.2% in 2003 and 2004 (despite a 55% increase of R&D expenditures), what is still far away from the EU-15 average.

In fact, all the promising figures at sector level cannot hide that there are also some drawbacks. For instance, according to some recently published labour market analyses a lack of suitably qualified personnel for R&D appears. Actually, the lack of qualified employees and university graduates with technical background was one of the reasons which led Skoda Auto towards the decision to build the university campus Na Karmeli. Obviously, the availability of highly qualified R&D personnel seems to be an ever increasingly important impeding factor for the expansion of R&D units in the NMS. Empirical evidence suggests within the NACE 34 a sector productivity growth higher than the labour costs growth, which is important for attracting FDI and keeping the sector internationally competitive. However, since more and more automotive companies are setting up their factories in the NMS it becomes increasingly difficult to get the adequately qualified people. It seems that the sector is suffering from its own success (and from the immigration of highly qualified people due to international salary disparities).

<sup>35</sup> As an example, the Soviet-Hungarian specialisation agreement from 1964 stipulated that Hungary would specialise in producing buses for the entire Council of Mutual Economic Assistance [CMEA]. Skoda was practically the only producer of cars in the NMSs with its own R&D unit. All other car manufacturers produced cars with licences from western companies. For more details on the history of the automotive industry in Central European countries, including recent developments, see e.g. Havas [2000a], [2000b], Pavlinek, [2002a], [2002b], [2003], [2005]

<sup>36</sup> It needs to be mentioned that the automotive sector in the literature commonly is classified as medium-low or medium-high R&D intensive sector.

Accordingly, extending and adjusting the national research infrastructures and the education systems, both a private as well as a public agenda point, returned to be in the focus. Admittedly, so far, there seems to be a communication gap among universities and their engagement in specific research tasks on the one hand side and the business sector on the other. There are many obstacles for co-operations between companies and (still mostly public) R&D institutions, such as the emphasis of universities on basic science instead of focussing also sufficiently on applied research and development of marketable product solutions, administrative barriers, etc. Although this problem is known from almost all EU countries it applies particularly to the CEE NMS where the NIS and the public research infrastructures had to undergo the transition process and a difficult adjustment period too, while suffering from significant budget cuts. Therefore, nowadays the public infrastructure in the NMS is simply lacking behind the business sector requirements. Given that, indigenous automotive suppliers (T2 & T3) are likely to be forced to step up their R&D efforts by setting up own R&D facilities and/or intend to achieve a closer intra-sectoral co-operation (accelerated cluster building). Along this way, most likely, R&D will play a role in the efforts made to extend the value chain in the car manufacturing within the NMS. But, although the sector is economically important, the potential of R&D-induced growth in low- or mid-tech suppliers industries (as this sector is commonly classified) should not be overestimated. Considering the quite promising sector trajectories in the light of the overall NMS trends concerning technological development, R&D and innovation, evidently, it remains a long way to go for the NMS in order to close the existing gap to the EU-15. In fact, automotive and parts as an emerging sector can certainly pull the technological development of the NMS economies by spill over and spin over effects. However, more such examples are needed. Accordingly, in the following a look at the Pharmaceutical industries of the NMS will be made.

## 6.2 Sector Study II: Pharmaceutical industries

The pharmaceutical sector (NACE 24.4) is, in general, one of the most R&D intensive and dynamic sectors and thus an interesting comparative case study also in terms of the NMS. The sector has been analysed individually by national research teams in Poland, Hungary and Slovenia. Complementary, in Latvia, Lithuania, Slovakia, Cyprus and the Czech Republic the chemical sector (NACE 24) has been considered assuming that this reflects the main tendencies of the incorporated pharmaceutical sector too and, therefore, can be taken here as an approximation. Table 4 provides the R&D intensities as well as their corresponding recent growth rates referring to the analysed sectors. This may illustrate the relative importance of the particular sector for each country and the role of R&D accordingly.

**Table 4: Sectoral R&D intensity, GDP share and investment dynamics**

			<b>Sectoral R&amp;D intensity</b>	<b>Change of R&amp;D intensity</b>	<b>Sector as % of national GDP</b>
	<b>NACE</b>	<b>Sector (manufacture of...)</b>	sectoral R&D as % of sector GDP 2003 or 2004	Ø annual change	2003 or 2004
<b>Cyprus</b>	24	Chemicals & Chemical Products	3.8%	113% (2001-2003)	0.5%
<b>Czech Rep</b>	24	Chemicals & Chemical Products	4.6%	65% (2001-2004)	1.4%
<b>Hungary</b>	24.4	Pharmaceutics, med. chemicals & chemical products	19.3%	-5% (2001-2003)	0.5%
<b>Latvia</b>	24	Chemicals & Chemical Products	1.9%	50% (2001-2003)	0.6%
<b>Lithuania</b>	24	Chemicals & Chemical Products	5.3%	974% (2002-2003)	1.0%
<b>Poland</b>	24.4	Pharmaceutics, med. chemicals & chemical products	n.a.	39% (2003-2004)	n.a.
<b>Slovakia</b>	24	Chemicals & Chemical Products	1.1%	unknown due to data protection	0.8%
<b>Slovenia</b>	24.4	Pharmaceutics, med. chemicals & chemical products	8.8%	19% (2001-2003)	3.3%

Source: EC (2006c), Private Sector R&D in the NMS; individual Country & Sector Studies and Synthesis Report.

According to Table 4, the pharmaceutical sector has indeed a quite significant GDP share in Slovenia. In all other NMS, both considered as sector aggregate NACE 24 or stand alone as NACE 24.4, it is rather unimportant for the National Accounts. However, the sectoral R&D intensity in general is comparably high in most of the NMS and it is particularly in those countries over-proportionally rising that are still lacking behind in this regard. Hence, there is a catching up in terms of sectoral R&D intensity, at least among the NMS laggards.

Moreover, the R&D growth rates appear to be the highest in those countries that have the lowest sector share in GDP. The latter indicates that the NACE 24 / 24.4 sector is indeed an emerging sector in a number of NMS economies and therefore of particular interest. In fact, over the last 10 years the pharmaceutical sector has been growing with respect to total size (in terms of sales and value added) as well as concerning R&D expenditures and R&D employees in most NMS. Some countries had drawbacks (e.g. Latvia in 1999), but have recovered recently. Only in case of Slovakia a more persistent decline of the sector (NACE 24) had to be observed.

Alike the case of the automotive sector, as described above, also the transition of the pharmaceutical sector has been dominated by the privatisation of large formerly state owned enterprises and by FDI. This led to a restructuring of R&D labs within larger organisations and, in some countries, also to a concentration of R&D in fewer R&D sites as happened for example in Hungary over the recent years. However, in general, the number of firms active in the sector appeared to be rather constant (which is in contrast to the automotive sector where it was found to be rising, see discussion above).

According to the absolute figures of R&D expenditures, Hungary<sup>37</sup> and Slovenia<sup>38</sup> are the most important R&D performers in the NMSs competing on global markets. In contrast, in Poland and the Czech Republic<sup>39</sup> enterprises invest much less; approximately only half of what is spent in Hungary. The latter means that, although the contribution of pharmaceuticals to the total GDP as well as the spending on R&D in Poland and the Czech Republic is rising, in both countries the R&D capability is supposed to be still quite low. In fact, with the exception of Slovenia and Hungary, the National Innovation Systems in NMS are (still) little oriented towards the pharmaceutical sector.<sup>40</sup>

In general, FDI appears to be the decisive factor of the sectoral development and the structural patterns of corporate R&D in the NMS pharmaceuticals. Nowadays, most large scale pharmaceutical companies in the NMS are subsidiaries of foreign MNCs, in Hungary for instance about 80%. However, in the pharmaceutical industry the sector concentration seems to be even higher compared to the automotive sector. In fact, T2 and T3 suppliers appear to be much less important, few in numbers and/or generally little dispersed. This is supposed to be mainly reasoned by the privatisation process. In course of the privatisation, the new - mostly foreign - owners have restructured the existing R&D systems, often reduced the number of R&D projects and narrowed the company's product range what has led to further specialisation, for instance in certain fields of product development and manufacturing. Particular emphasis was given to the production of generics, a field where the NMS companies traditionally had competencies. But, following this business and innovation strategy, most pharmaceutical companies in the NMS are currently carrying out applied R&D solely even though the development of fundamentally new drugs appears to be essential for their competitiveness in the mid/long run and, therefore, also for their survival. As a critical side effect of this specialisation strategy possible co-operations with domestic research infrastructures (universities and research organisations) have been limited. This environment may appear particularly struggling

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<sup>37</sup> Hungary's pharmaceutical sector has grown faster than the entire chemical sector and appears to be the most R&D intensive sector in Hungary (R&D expenditure growth of about 20% annually 2001-2003). Total sales and value added also grew remarkably between 1997 and 2004, mostly triggered by rising productivity. Thus, evidence suggest that the sector in Hungary is more capital intensive than in Slovenia. In 2002, 25% of the R&D personnel in Hungary were spending 35% of national BERD, whereas 15% of Slovenia's R&D personnel were spending 30% of national BERD. This might be explained by differences in the overall labour productivity (higher in Slovenia) and/or by the country specific enterprises structures.

<sup>38</sup> R&D expenditures in Slovenia almost sevenfold between 1992-2004, even though only two firms are doing R&D.

<sup>39</sup> In 2004, the R&D expenditures in the Czech chemical industry reached 50 mio. EUR. In fact, expenditures were decreasing in the first half of the 1990s affected by the privatisation. However, during the period 1995-2004 it doubled. The intramural private R&D expenditures in the pharmaceutical industry (NACE 24.4) reached almost 62% of R&D expenditures in NACE 24 and the share of NACE 24.4 increased significantly in recent years (49% in 2003).

<sup>40</sup> See European Commission (2006): Private Sector R&D in the NMS, Synthesis Report, pp. 59 – 65.

for innovative newcomers since both domestic push as well as pull factors seem to be un-incisive and spin-offs in this environment are supposed to be quite difficult too.<sup>41</sup>

In fact, start-ups have generally been found very weak (and few) across the NMS studied and, however, no significant (domestic) demand pull factors<sup>42</sup> in terms of the pharmaceutical sector could be identified. Moreover, in some NMS the companies seem to have problems to cope with the EU quality (safety) standards for pharmaceutical products (particularly in Poland) and also with applying some recently introduced common environmental protection regulations. The implementation of REACH [Registration, Evaluation and Authorisation of Chemicals] also appears to be a major challenge for any company in the sector (not only in NMS). Finally, company interviews revealed that currently the availability of adequately qualified human resources, previously a plus factor of the NMS, more and more becomes an impeding factor of their development.

In the light of the significant R&D intensity growth rates (see Table 4 above) these drawbacks need to be pointed out, although, on the other side, the increased R&D spending – triggered by FDI – certainly has provided a substantial knowledge and technology inflow and also opened the doors for international co-operations via the networks of the multi-national parent companies. Accordingly, the situation in the pharmaceutical sector of the NMS can be summarized as promising in the sense of converging R&D intensities (and getting closer to the EU-15 in this regard), but, however, struggling with pitfalls of some unfavourable recent developments. There is evidently still a long way to go in order to fully catch up with the frontier setters of the pharmaceutical sector elsewhere.

### **6.3 Conclusion of the sectoral considerations**

Based on the two sector studies discussed above it can be summarized that disaggregated considerations of R&D intensity and the corresponding trend patterns may indeed provide a differentiated picture compared to the aggregated figures. In fact, there is catching up in terms of R&D in the NMS, but the evidence is restricted to a few sectors only; particularly to such sectors as discussed above, which are emerging but have not (yet) achieved to be substantial pillars of the NMS economies. Accordingly, the mentioned positive developments appear to be (still) superimposed by other less dynamic or even reverse trajectories in other parts of the national economies.

Thus, given the heterogeneous and even diverging R&D figures among the NMS as discussed above in aggregated terms, the emerging sectors with the outlined dynamic R&D trajectories might be seen more as 'bright spots' rather than being the heralds of a common catching up. Moreover, the fact that country-level aggregated and sector-level considerations may provide differentiated pictures calls for a complementary analytical focus on firm-level trajectories. In fact, the individual sector studies indicated a number of companies in each sector performing R&D quite successfully, making the pace and, however, setting the frontiers even if these frontiers may refer to the production possibility set given the particular environment of a certain country only. This finding implies that there might be also a number of companies that are laggards in this respect.<sup>43</sup> Accordingly, the sectoral picture that has emerged may once again superimpose several differentiated trajectories at individual firm level.

In general, empirical analyses at the firm-level may bring us closer to an answer concerning the question whether the NMS are already catching up or not. However, this cannot be done here,<sup>44</sup> but it

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<sup>41</sup> In general, only little evidence of such effects could be found across NMS. However, in Lithuania some spin-off activities were observed (biochemistry).

<sup>42</sup> Specific national market demand conditions, e.g. by close co-operations with hospitals, universities, key scientists, etc. could create some niche markets and thus help to explore national competitive advantages.

<sup>43</sup> In course of the sector studies four basic types of companies have been identified: (A) type companies: autonomous domestic players that manage to initiate and implement their own R&D strategies and operate on domestic and/or international markets (e.g. financial intermediaries in Estonia, biotech niche players in Lithuania); (B) companies: firms that are embedded in global R&D networks and are mostly subsidiaries of foreign companies (e.g. automotive, pharma); (C) companies: firms that perform adaptation-oriented R&D in order to adapt existing products and services to local market needs and regulations (e.g. telecom equipment providers, IT services); (D) companies: firms with invisible R&D which is embodied in services or a cross-cutting activity in the companies' organisational units (e.g. service providers, SMEs).

<sup>44</sup> Apart from the fact that this could be done in a number of representative case studies only, the access to comprehensive micro-level data for analysing relationships between R&D, innovation, relevant firm characteristics and the company's ultimate performance is quite difficult, not at last due to the sensitiveness and confidentiality of individual firm data.

is currently a matter of interest in a number of projects as e.g. analysing corporate R&D at firm level in different sectors comprising distinctive R&D intensities,<sup>45</sup> taking into account firm size patterns (e.g. SMEs), R&D environmental issues at certain regional levels,<sup>46</sup> etc. Thereby, it should be particularly analysed what implications may have the above mentioned pitfalls and drawbacks in relation with the outlined favourable framework conditions for R&D in the NMS in a mid to a long term perspective. This certainly may help getting a clearer picture of the convergence trend patterns.

Aside, in the literature<sup>47</sup> some methodological approaches can be found allowing for a differentiated consideration of convergence, usually called "Conditional Convergence", Beta-, Sigma- Convergence, etc., often applied in productivity analyses and convergence considerations of GDP growth patterns. Although this is supposed to be very interesting for complementing the present analysis too, the heterogeneity of those circumstances identified to impede or foster the economic transition of a particular NMS as well as the corresponding R&D patterns prevent here the application of such an approach.<sup>48</sup> In fact, filtering all these effects out of the data would – most likely – again lead to the situation that any relevant patterns are superimposed by others (and/or get removed in course of the data set adjustments), which finally would allow only a biased picture anyway and may appear to be an eyewash, neglecting the obvious trends and looking for any possible hidden patterns behind. Therefore, for the current consideration the application of this methodology is skipped. However, for any future analysis of the subject, particularly if going more in detail (e.g. at firm-level) or relying on longer time series, such an approach might be applicable and could disclose interesting insights.

## 7 Determinants of current R&D trajectories in NMS: What really matters?

According to the examination of R&D dynamics at country, sector, and partly company levels there is, at least currently, no common trend pattern uniformly evident in all NMS rather than a wide heterogeneity; and this picture seems to become even more diversified as more disaggregated the analysis is performed. However, for anticipating future developments and also for policy making perhaps even more relevant as searching for convergence in terms of R&D are the determinants and main drivers of the corresponding trajectories.

In fact, what actually prevents NMS to catch up faster?

The answer is complex and, once again, country/sector specific. For instance, above in aggregate figures, some countries have been identified as catching up to the EU-15 in terms of R&D intensity, some are keeping a constant level and some apparently are diverging. By looking at R&D expenditure patterns this has been attributed rather ad hoc to the government and/or to the business sector. Looking at it more in detail, indeed, a more differentiated picture emerges. Regrettably, identifying the individual drivers of the trajectories for each NMS/sector – namely the impeding and fostering factors while taking into account all the mentioned superimposing effects – would go beyond this analysis by far. Nevertheless, based on the individual country and sector studies some main R&D determinants can be identified as cross-cutting issues being analogously relevant for the NMS in general:<sup>49</sup>

First of all, **FDI** appears to play a very significant role in many sectors in the NMS (see e.g. automotive and pharmaceutical sector), implying a more or less tight embedding of the R&D investment in the overall R&D strategy of a multi-national firm. This development – while being generally perceived as very positive – has a number of double-edged impacts on the evolution of the R&D base in the NMS. On the one hand, foreign investments tend to contribute to the upgrading of

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<sup>45</sup> See Sector Study: Framework Service Contract 150083-2005-02-BE; EC (2006c)

<sup>46</sup> See ERA-Analysis: [http://iips.jrc.ec.europa.eu/activities/research-and-innovation/era\\_analysis.cfm](http://iips.jrc.ec.europa.eu/activities/research-and-innovation/era_analysis.cfm)

<sup>47</sup> See for example Gutierrez, L. (1999) exemplary for a study on EU accession and growth patterns or Ragnitz et al. (2001) for an overview of convergence measures (Beta-, Sigma-, ...) and an application on spatial/sectoral convergence.

<sup>48</sup> Moreover, the low number of relevant observation points (short time horizon in case of NMS) would also weaken the analytical value of the corresponding estimates.

<sup>49</sup> Annex II (project Synthesis Report, see below) provides more details and summarizes the mentioned individual country studies.

the managerial knowledge and organisational competencies as well as diffusion of new technologies. On the other hand, the embedding in a global company's R&D strategy often entails a narrowing of the scope of the R&D performed in the country concerned. This, in turn, has consequences for the spectrum of R&D collaboration with domestic universities and research centres. In this context it is also worth noting that the type of R&D that is being performed by enterprises in the NMS appears to be less basic research oriented than in countries hosting the headquarters of MNC. Indeed, it is much more focused towards specific niches (e.g. pharmaceuticals in Hungary), as well as adaptation-oriented in the sense that restructuring and modernisation of the economy is still taking place to a noticeable extent (e.g. R&D in financial intermediaries in Estonia). Moreover, due to the internal competition between R&D locations of a MNC, there is a non-negligible risk that these activities may move elsewhere if the conditions for R&D or the overall R&D strategy of the company change. The maintenance of private sector R&D activities by means of FDI thus comes at the price of uncertainty about the sustainability of this investment. However, in the end, the extent to which R&D might become footloose depends on the quality and continuous improvement of the factors and conditions due to which R&D-investment were initially set up (and maintained!) in a specific location.<sup>50</sup>

The sector case studies have shown that the reasons for foreign investment in R&D can be manifold. Of outstanding importance for any investments in R&D in the NMS seems to be a combination of three factors: (1) the quality of the available human resources, (2) the labour costs, and (3) the access to local markets. However, each factor might be also seen stand alone as a main determinant of the R&D trajectories in the NMS impeding or fostering the corresponding trends (as discussed below).

In fact, the availability of **highly qualified R&D personnel** is widely acknowledged as strength of many NMS, often building on a long-standing industrial tradition in the respective sector (e.g. Czech automotive industry, pharmaceutical industry in Hungary and Slovenia). However, growing R&D investments, be it in the business or in the public sector, are likely to exhaust the capacities of the local labour markets in terms of qualified staff. In some cases a lack of staff for performing R&D is already reported. This is attributed to the brain drain and over-ageing process (e.g. Estonia, Latvia, and Lithuania). Moreover, the intention of most NMS to invest EU structural funds into R&D infrastructure and innovation projects may also raise pressure on the HES in the NMS to provide the research staff needed. While this problem may disappear in the mid/long run by reinforcing efforts to educate a new generation of engineers and scientists, it may lead to a scarcity of qualified personnel in those locations where already now substantial further investment in manufacturing and/or R&D is planned (e.g. in the automotive industry in the Slovak Republic). The least that can be concluded from this observation is that it is not very likely that the NMS will be able to provide a labour force reserve of high skilled employees compensating the foreseeable shortages in the EU-15 countries.

**Labour costs** have been a major advantage of the NMS, particularly in production but also in terms of R&D. Empirical evidence suggests that some NMS are already facing diminishing competitive advantages due to growing wages (e.g. in Estonia). Although this factor was not reported to be "highly important" in course of the sector studies it may appear to be increasingly important in the future.

Finally, **domestic markets** also tend to play a particularly important role regarding the local embedding of R&D. While some foreign R&D investments were motivated by the ease of access to the enlarged internal European market, in some NMS also the domestic markets are economically quite interesting. This holds, for instance, for the pharmaceutical industry where specific conditions and relationships prevail with hospitals and R&D infrastructures, thus offering opportunities that are favourable for the creation of niche markets. Moreover, for instance observed in terms of the IT services in Estonia, the combination of qualified personnel and demand for an upgrading of service quality was conducive to the establishment of a strong national R&D market.

In contrast to these evident key factors, it is difficult to assess the impact of a number of framework conditions supposed to be beneficial for performing R&D, like for example tax incentives. While they certainly matter for specific decisions, a corresponding survey conducted in course of the individual

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<sup>50</sup> In fact, a sustainable embedding of R&D might not always be guaranteed in the case of FDI. Localised R&D could on the one hand lead to local value added. On the other hand, FDI might skim the cream of high-potential researchers in labs that produce footloose R&D for value added elsewhere in the world. In the NMS there is evidence for both.

NMS analyses tends to suggest that their importance seems to be over-estimated. If available, specific incentives are welcome, but the main determinants of investments in R&D apparently lie elsewhere (see key factors above). In fact, although R&D support measures as well as international technology and know-how transfers may bring important knowledge to an economy, that alone certainly is not enough. Using new technologies efficiently requires creating additional absorptive capacity, while a continuous effort has to be made to keep up with technical change. This is particularly true given the fact that wages tend to rise as a country develops, facilitating the entry of lower cost competitors in the market, both currently observable in the NMS.

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## Annex I Agenda of the Workshop

### Workshop

# The role of private sector R&D in the catching up of NMS

hosted by JRC-IPTS, Knowledge for Growth Unit

Seville / Spain, 13 - 14 December 2007

## Agenda

Thursday, 13 December 2007

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10:30 – 10:50 **Welcome address to participants & general introduction**

- *The workshop in the context of the JRC-IPTS / KfG / IRI work*  
Xabier Goenaga (JRC-IPTS, European Commission)

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10:50 – 11:30 **Synthesis of previous work in the light of recent empirical evidence**

- *outlining of the workshop's objectives and research questions*  
Andries Brandsma & Peter Voigt (JRC-IPTS, European Commission)

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11:30 – 13:30 **R&D in the context of the economic situation in NMS: Emerging trends**

Karel Aim, Michal Pazour	Czech Republic
Zoran Aralica	Croatia
Constantin Ciupagea	Romania
Maija Kale	Latvia
Tarmo Kalvet	Estonia
Monika Kriaucioniene	Lithuania
Snezana Krstic	Serbia
Teoman Pamukcu	Turkey
Tamás Polgár	Hungary
Peter Stanovnik	Slovenia
Marzenna A. Weresa	Poland

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13:30 – 15:00    **Lunch Break**

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15:00 – 17:30    **Discussion of possible future avenues of research in the field (Steering Com)**

Karel Aim  
Constantin Ciupagea  
Peter Stanovnik  
Marzenna A. Weresa

## Friday, 14 December 2007

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09:15 – 09:30    **Summary of yesterday's presentations and discussions**

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09:30 – 11:30    **Presentation of contributed papers**

- *The role of the private sector R&D in economic convergence through innovation in Croatia*  
Zoran Aralica
- *R&D activity in Romania before and post-accession into the EU. The interrelation of R&D with the economic development*  
Constantin Ciupagea
- *Role of Private Sector R&D in Turkey*  
Erkan Erdil/Teoman Pamukcu
- *Developments in corporate sector R&D in Serbia*  
Snezana Krstic

11:30 – 12:00    **Coffee break**

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12:00 – 13:00    **Discussion**

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13:00 – 13:30    **Closure of the workshop**

# **Annex II Final Report of the ETEPS study on Private Sector R&D in the NMS**



## **PRIVATE SECTOR R&D IN THE NEW MEMBER STATES**

### **FINAL REPORT**



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## Executive summary

Increasing private sector R&D is of vital importance for the medium- to long-term economic development perspectives of the New Member States. In this context, the 3% Barcelona target for R&D expenditures represents an important objective and challenge. It requires more than a doubling of current levels of R&D spending, to which the private sector is expected to contribute two thirds. In order to get an as accurate and up-to-date picture as possible of private sector R&D at sectoral level, this study provides policy makers with up-to-date information and details on private sector R&D in the New Member States (NMSs). It focuses on sectors which are contributing or have the potential to contribute significantly to economic activity. Four sectors have been studied in each country whereas ICT related sectors have not been addressed which are covered within a separate project by the IPTS.

The study covers sectors of economic activity in each of the ten new Member States: Cyprus (CY), the Czech Republic (CZ), Estonia (EE), Hungary (HU), Latvia (LV), Lithuania (LT), Malta (MT), Poland (PL), the Slovak Republic (SK) and Slovenia (SI).

The **objectives** of this project are:

- to give an as accurate and structured **overview of patterns, determinants and impacts** of R&D investment in the NMSs as possible,
- to help **assess the availability, reliability and quality of data** on R&D investment in the NMSs.

The **availability of data** is documented in a matrix covering 24 indicators. The matrices for each country can be found as an annex to this report. The matrices cover information on all available sectoral data of the national economies and indicate for which years data are available.

The following overall observations can be made regarding data availability:

- There is a gap in availability of data between EUROSTAT and the national statistical offices. Generally speaking, data are available at more detailed sectoral level in the national offices than published by EUROSTAT.
- Availability of data differs between larger and smaller NMSs. In some sectors on NACE 3 level data are not published due to individual data protection in the case of limited number of enterprises involved (e.g. automotive industry in Slovakia).
- No general pattern of gaps can be found, however, the weakest category of indicators in terms of availability are indicators related to sources of funding of R&D activities

The reliability of sectoral data is considered to be high. All data sources are based on Frascati Manual or Oslo Manual (for CIS). Caveats are mainly due to changes in the method of R&D survey, but date back to the 1990s.

### Country Case Studies

The report provides brief summaries of the **country studies** including statistical material on the R&D expenditures and R&D personnel employed for each of the selected sectors. Details on the sectors based on statistical material, secondary data analysis and company case studies can be found in the individual country reports.

As shown by the **sectoral case-studies** in this project, the patterns, determinants and framework conditions of private R&D investment in New Member States are **very heterogeneous**. This heterogeneity is to a significant extent a reflection of the respective national and sectoral „R&D histories“, i.e. a result of path-dependencies. Specifically in the former communist countries, it becomes obvious that the division of specialized industries and related research efforts between the countries of the eastern block economic alliance still influences the importance of the different sectors and their R&D intensity. In the Czech Republic, for instance, R&D activities in car manufacturing were high. This is still reflected in today's economic structure of the country and the private R&D expenditure in the sector. Other countries like Slovenia, have never had a significant share in the automotive sector or were specialised in niches as Hungary illustrates. The heterogeneity of the sectoral case studies is also partly determined by the size of the countries. Countries like Malta or Cyprus hardly show any R&D activities. Larger countries like Poland, Czech Republic have a longer tradition in R&D activities.

Moreover, the current situation is still very much in flux; the processes of industrial transformation and integration in the global economy have not yet settled. These general observations imply that any recommendations to policy should be based on a **sectorally and nationally differentiated interpretation of patterns of private R&D investment**. This is consistent with the recent trend in research and innovation policy research to stress the integration of RTDI-policies into stronger industrial or sectoral policies (Malerba 2004). Although a differentiated perspective seems to be appropriate from a conceptual point of view, it turned out to be very difficult – at least in some countries – to underpin the transformation with statistical data. In some countries (Malta, Cyprus, Lithuania and others) this is simply a matter of data availability, in others the interpretation of data is not unequivocal due to problems of confidentiality (e.g. Slovakia), inappropriate international statistical standards (e.g. in services). In the smaller NMSs it is a matter of scale of the sector (Malta, Cyprus, Lithuania, Latvia, Estonia).

In spite of a call for a differentiated and cautious interpretation of private R&D investment data, some **cross-cutting observations** can nevertheless be made.

First of all, **foreign direct investment** (FDI) tends to play a very significant role in many sectors (automotive, pharmaceuticals), implying a more or less tight embedding of the R&D investment in the overall R&D strategy of a multi-national firm. This development – while being generally perceived as very positive – has a number of double-edged impacts on the evolution of the R&D base in a country. On the one hand, foreign investment tends to contribute to the upgrading of the managerial knowledge and organisational competencies as well as diffusion of new technologies by way of FDI (overall and/or R&D). On the other hand, the embedding in a global company's R&D strategy often entails a narrowing of the scope of the R&D work performed in the country concerned.

The availability of **highly qualified R&D personnel** is widely acknowledged as strength of many New Member States, in many cases building on a long-standing industrial tradition in the respective sector (e.g. Czech's automotive industry, pharmaceutical industry in Slovenia). However, growing R&D investment be it in the private sector or in the public sector is likely to exhaust the capacities of the local labour markets in terms of qualified staff in the foreseeable future. In some cases a lack of scientific staff for R&D is already reported. This is caused by brain drain and over-aging (e.g. Estonia, Latvia, Lithuania). The intention of most NMSs to invest the foreseen EU structural funds into R&D infrastructure and innovation projects, will also create a pressure on the countries educational system to provide the research staff that contribute in a sustainable way to the creation of knowledge.

**Labour costs** have been a major advantage of the NMSs, particular in production but also in R&D. Some sectoral studies show that national politics is already faced with the diminishing competitive advantage by means of growing wages (e.g. in Estonia). Although this factor was not reported to be that important in the sectoral studies, this factor is frequently named as important (e.g. in the ICT sector)

As a third key factor, **home markets**, tend to play a particularly important role with respect to the local embedding of R&D. While some foreign R&D investment was motivated by the ease of access to the large internal European market, in some sectors the national markets are also an important argument for investment. This holds, for instance, in the pharmaceutical industry where specific conditions and relationships prevail with hospitals, universities and key scientists, thus offering opportunities that are favourable for the creation of niche markets.

A sustainable embedding of R&D might not always be guaranteed in the case of FDI. Localised R&D could on the one hand lead to local value added. On the other hand FDI might skim the cream of high-potential researchers in labs that produce “footloose” R&D for value added elsewhere in the world.

As compared to these three key factors, it is difficult to assess the role of favourable framework conditions (e.g. tax incentives). While they certainly matter for specific decisions, the interviews conducted in the course of the project tend to suggest that their importance seems to be over-estimated. If available, specific incentives are welcome, but the main determinants of foreign investment lie elsewhere, e.g. in the lower labour costs and emerging markets.

From this analysis, a number of issues arise that cut across as critical for the future and thus are requiring particular policy attention:

- The consideration of national and sectoral innovation systems to ensure the embedding of R&D;
- The future development of the human resources base as a pre-condition for performing R&D and thus for attracting R&D investment;
- The continuous improvement of the innovation infrastructure (universities, research centres, etc.), not only as sources of qualified R&D personnel, but also as potential partners for industrial R&D;
- A growing attention to the role of services, either as stand-alone research-intensive activities (e.g. KIBS) or as support services to R&D performed in other sectors (e.g. standardisation, IT services);
- Improving the innovation climate by structural measures rather than by financial incentives. This concerns, for instance, also the strengthening of the relationships between different innovation actors, private and public ones. There are already some examples of private firms getting engaged in funding of R&D centres or university institutes;
- Bundling of national R&D capacities (e.g. through national technology platforms) and seeking a better coordination with European initiatives.

## **Motor vehicles and related Industries**

The sector of car manufacturing (NACE 34) was in focus of the national research teams in Czech Republic, Poland, Hungary and Slovakia, due to its present or foreseeable importance for the national economy. Other sectors, extending the value chain were included in the analysis: the production of tyres in the Czech Republic and Slovakia (NACE 25), and electrical equipment for engines and vehicles in Hungary (NACE 31.61).

### **Pattern of R&D**

There is a big difference in the importance of the automotive sector in the national economies in terms of value added. The share of private R&D expenditure also varies significantly between countries. The automotive sector is most important in the Czech Republic. The sector contributed 2 bn. EUR or 2.7% to the GDP with 7% of Czech employees working in the sector in 2004. The relative importance of the sector is 2.5% of GDP in Hungary and Slovakia and 1.5% in Poland. In the Czech Republic, the sector's R&D expenditure was around 180 mio. EUR in 2004. R&D expenditure as a percentage of GDP is above EU average in NACE 34 in the Czech Republic. In Hungary, Poland and Slovakia it is below average. But, unlike in the Czech Republic, with stagnating R&D expenditure, growth rates in these countries were between 54% and 114% over a two to four year period.

### **Determinants of R&D investment**

The automotive sector is a dynamic sector in many NMSs with differing levels of R&D intensity. The development of the automotive sector over the last years took various paths and cannot be described as a single phenomenon due to individual historical determinants. The Czech Republic, for instance, has a long tradition in car manufacturing while other countries are specialised more on trucks or motors.

The two main arguments for investors in this sector are lower **costs** vis a vis the old member states of the EU and the **emerging opportunities** to get a foot into the enlarged European market. **Foreign direct investment (FDI)** is the main determinant of the expansion of the sector. Investments are either secured by take-over of existing firms or in some cases by joint ventures. Investments are either brown-field or green-field types of investments. Slovakia currently manufactures over 250 thousand cars per year. This investment by PSA Peugeot Citroen and Hyundai Kia for final assembly plants will nearly triple automotive investment output by the end of the decade. These developments may as well lead to an increase in R&D intensity in the future.

### **Framework conditions**

Apart from legal regulations (e.g. REACH), the sectoral production system is characterised by standardisation efforts which are caused by the three tier-system. The impact of tax incentives has not yet been evaluated. The availability of highly qualified R&D personnel seems to be an ever increasingly important factor for the expansion of R&D units in the NMSs. Some recently published labour market analyses point out the lack of suitably qualified personnel for R&D. Lack of qualified employees and university graduates with technical background was one of the reasons which led Skoda Auto towards the decision to build the university campus "Na Karmeli". The public support in setting up technology parks which will be subsidised by EU structural funds in the future might be an additional incentive to attract R&D units.

### **Impact of R&D**

The direct impact of R&D activities is reported in only very rare cases. Doubtless, there is a large impact of technologies and processes that were brought to the NMSs by FDI. Productivity rates are rising in the sector in most countries which can be explained by intra-firm knowledge transfer.

### **Pharmaceuticals (argument-because of traditionally high R&D)**

As the pharmaceutical sector allows to study R&D dynamics at the front end of technological development and since some pharmaceutical companies have played a significant role in nearly all NMSs, the pharmaceutical sector has been chosen to be studied and compared across the NMSs. The pharmaceutical sector has been studied in Poland, Hungary, Slovenia, Latvia and Slovakia. However, so far, only for the first three countries figures are available describing the R&D development of the pharmaceutical sector (NACE 24.4.), which is a sub-sector of the chemical sector, while for the others, R&D data are only available for the chemical sector.

### **Pattern of R&D**

With respect to the value added of the sector, the pharmaceutical sector has the highest share in Slovenia's economy (3.3%) and a share below 1% in the other countries. The sector has thus a minor relative importance in most NMSs compared to other westerly countries. The absolute figures of R&D expenditure show that Hungary and Slovenia are the most important R&D performers in the NMSs competing on the global market. Apart from Slovenia and Hungary, the National Innovation Systems are thus obviously not very much oriented towards the pharmaceutical sector. However, in general, the pharmaceutical sector has been growing with respect to value added, R&D expenditures and R&D employees in all countries.

### **Determinants of R&D investment**

The successful privatisation of former state-owned large enterprises and FDI are the most significant **driving factors** for the development of the pharmaceutical sector. In most coun-

tries, the largest firms are now subsidiaries of foreign MNCs which also led to a restructuring of R&D labs within larger organisations. This restructuring process has led to a concentration of R&D activities in fewer R&D sites and to a reduction of the product range. However, all in all, the number of firms has not changed significantly. Slovenia is an exception in so far as the largest pharmaceutical firm is still partly nationally owned since it span off from a merger of a Czech and Slovakian firm. FDI have also opened up new opportunities for international co-operations via the networks of the multi-national parent companies. However, this can also have a side effect as the Hungarian case demonstrates: The aforementioned development limited the co-operation with domestic universities due to the high specialisation of R&D. In this context, the case studies reveal that the research infrastructure plays a minor role in the different countries concerning the development of the pharmaceutical sector as scientific source for drug development and co-operation partner. The links to the national research infrastructure seem to be rather weak in most countries. Nevertheless, there are also some examples of firms which have successfully exploited the national research capacity as Latvia and Lithuania demonstrate. In these two countries, pharmaceutical companies have successfully specialised in niche markets internationally.

In the last century, the R&D strategy of the majority of pharmaceutical firms in the NMSs was mainly based on the **production of generic products**. Following this business and innovation strategy, most pharmaceutical companies are now carrying out applied R&D, even though the development of new drugs and the ability to develop or discover new molecules is becoming increasingly important to remain competitive in the long run. Cases in Hungary, Slovakia and the Czech Republic show that firms were not only successful in improving production processes but also in mastering the product innovation challenge.

### Framework conditions

At the moment, **human resources** seem to be the most critical hampering factor for the further development of the sector. The lack of qualified scientists due to lower attractiveness of natural sciences among students, brain drain and ageing of researchers is a serious problem in most NMSs. In contrast, rising demands related to regulation and quality management seem not to be a serious hampering factor. Except for Poland, most countries have already mastered the challenge of coping with new regulations for the approval of new drugs and the necessary quality and safety standards. Poland has still a particular problem with quality management and safety regulations which has delayed the development of the sector in the last few years and requires further foreign capital in the future.

### Impact of R&D

In general, investments in R&D have helped to increase productivity, in particular with respect to the production of generic products, in some cases even the development of new pharmaceuticals. Thus, increasing R&D investments has most likely fostered growth and kept companies competitive in the NMSs. However, **newly established firms**, spin-offs and start-ups hardly play a role in the R&D performance of the NMSs. Even though the pharmaceutical sector increased its competitiveness in the past, in general, perspectives appear to be rather unfavourable. It remains unclear if the sectors in all NMSs will be able to grow in the future under the given framework conditions. The main challenges will be to build capacities for developing new molecules, to closer co-operate with domestic research institutes, and to develop the necessary qualification of human resources to match the needs of the sector.

### Further research

This study has been of an exploratory nature and was not meant to deeply investigate all aspects that would have been worth investigating. However, it was going into sufficient depth to identify a number of research needs for the future. These can be subsumed under five main headlines:

- Data availability (to be based on analysis of availability matrix),
- Broadening and deepening the empirical base,,
- Impacts of private sector R&D,



- Impacts of policy measures.

## I. Introduction

Business enterprise expenditure on R&D (BERD) in all new Member States (NMSs) in 2003 was below the EU average of 1.23% of GDP, which makes the overall Barcelona target of 3% of GDP for gross domestic expenditure on R&D, of which two thirds are financed by the private sector, an even greater challenge for them than for other member states. A continuation of low levels of private R&D in the new Member States may also hinder the catching-up and integration of their economies into the EU.

To reach the Barcelona target of approaching 3% of GDP for gross domestic expenditure on R&D, considerable efforts will have to be made by the NMSs. Policy makers within these countries need to have up-to-date information on the status, the determinants and the impacts of private R&D investment.

This study provides policy makers in the EU and the Member States with up-to-date information and details on private sector R&D in the new Member States. It focuses on sectors which are contributing or have the potential to contribute significantly to economic activity (4 sector studies in each country). In specific cases, the sectoral analysis is also illustrated by case studies of individual firms.

The study covers sectors of economic activity in each of the ten new Member States: Cyprus (CY), the Czech Republic (CZ), Estonia (EE), Hungary (HU), Latvia (LV), Lithuania (LT), Malta (MT), Poland (PL), the Slovak Republic (SK) and Slovenia (SI).

The **overarching objectives** of this project are:

- to give an as accurate and structured **overview of patterns, determinants and impacts** of R&D investment in the NMSs as possible,
- to help **assess the availability, reliability and quality of data** on R&D investment in the NMSs.

More specifically, the following **operational objectives** are pursued:

1. collect statistical (and other) data on **key patterns, the nature and the sources of R&D investment** at sectoral level in the NMSs,
2. assess the **impact of framework conditions** on R&D investment at sectoral level

The report begins with describing the selection of industries, the data sources used and the availability and reliability of data in a section on methodology. In a second section for each of the NMSs an overview is given on private R&D in four selected sectors. To be able to give a more detailed overview on specific sectors two sector were chosen: automotive and related industries and pharmaceutical industries. For these two synthesis-chapters patterns, determinants, framework conditions and impacts of private R&D are described using information from those countries who investigated these sectors. In a concluding chapter cross cutting issues are discussed to learn from the sectoral studies performed. Furthermore, future research needs are discussed. In the Annex the availability of data on 24 private R&D indicators is documented for each country.

As the information collected in the individual country reports is too voluminous, it is not included in the final report. Details on the sectors based on statistical material, secondary data analysis and company case studies can be found in the individual country reports, which will be available at the ETEPS website.

## II. Private R&D in New Member States

### 1. Method

In order to achieve the specific project objectives as described above, quantitative and qualitative analyses at sectoral level were combined with company-level case studies.

In conceptual terms, the project builds on the framework of Sectoral Systems of Innovation (SSI).<sup>1</sup> According to this approach, sectoral factors such as the nature of the knowledge base, the interaction and role of different actors such as suppliers, universities and users as well as institutions are considered explicitly to study the nature of the innovation process and outcomes in various sectors. The IPR regime, concentration of industry, knowledge characteristics (stickiness, appropriability, tradability), etc. are important factors for the scope of R&D activities, and thus of R&D investment.

The overall architecture of the project approach was as follows:

- Specification of the methodology: Agreement on a common understanding of the approach and the methodology of data collection among project partners.
- Pre-screening: A pre-screening of international data sources was conducted.
- Sectoral analysis: The analysis of R&D investment concentrated on the level of sectors, but required complementary information on national framework conditions.
  - Country level analysis: The analysis at the country level focused on those aspects that are essential for the implementation of the sectoral and company-level case studies, for instance, in relation to framework conditions to be taken into account.
  - Sectoral level analysis: At sectoral level, statistical data sources were exploited as far as possible in order to deal with the patterns, sources and nature of R&D expenditures, to be complemented by other secondary sources. The role of framework conditions and the impact on company performance are based on some selected statistical sources (e.g. CIS data where available) and existing studies, but mainly relied on anecdotal information by means of company case studies.
  - Availability and reliability check: The analysis at international, country and sectoral level feed into an assessment of availability and reliability of statistical and secondary data sources.
- Company level: Between 2 and 4 company case-studies were conducted per country by means of analysing company reports and conducting interviews in order to deepen the understating of R&D activities and their determinants at the firm level.

#### 1.1. Selection of industries

For each country four sectors are covered, selected from a list of manufacturing and service sectors on the basis of their R&D intensities (R&D/GDP), the recent rise in these figures and the contributions to GDP of these sectors. The two sectors with the highest R&D intensities were chosen, accompanied by the two sectors with the highest increase in R&D intensity in recent years. Initially, for the first two sectors the selection criteria included using a minimum threshold of 2% for their contributions to GDP and 1% for the first two sectors' contributions to GDP. This second criterion was not used in all cases, mainly when the NACE two-digit level

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<sup>1</sup> See Malerba, F. (ed.) (2004): Sectoral Systems of Innovation. Concepts, Issues and Analyses of Six Major Sectors in Europe, Cambridge University Press: Cambridge

was evaluated as too diverse to answer the research questions, and thus NACE three-digit data were used and analysed (e.g. in the case of pharmaceuticals) instead. Moreover, one sector had to be common to all or at least most countries to enable some comparative analysis.

The ICT sectors were not included in the selection for this study as information about ICT sectors is covered by a separate IPTS activity within the JRC Enlargement and Integration Action.

All sectors considered correspond to the NACE standard classification.

Based on the selection criteria and the discussion on the selection of sectors at the kick-off meeting, the following sectors were chosen for sectoral studies (see Table 1)<sup>2</sup>.

**Table 1: Selection of Sectors for the Sectoral Studies**

Country	NACE code	Sector	R&D intensity private R&D investment as % of sectoral GDP (2003 or 2004)	Increase in R&D intensity (%)	Sectoral GDP as % of national GDP (2003 or 2004)
Cyprus	45	Construction	0.01%	10% (2001-2003)	7.3%
	24	Manufacture of Chemicals and Chemical Products	3.8%	113% (2001-2003)	0.5%
	29	Manufacture of Machinery and Equipment	0.8%	0% (2001-2003)	0.2%
	65	Financial intermediation except insurance and pension funding	0.03%	1286% (2001-2003)	5.6%
Czech Republic	34	Manufacture of motor vehicles, trailers and semi-trailers	8.8%	5% (stable) (2001-2004)	2.7%
	24	Manufacture of chemicals and chemical products	4.6%	65% (2001-2004)	1.4%
	25	Manufacture of rubber and plastic products	0.9%	91% (2001-2004)	1.6%
	31	Manufacture of electrical machinery and apparatus n.e.c.	1.8%	104% (2001-2004)	1.8%

<sup>2</sup> In Estonia, the non-ICT sectors of 'Manufacture of electrical and optical equipment' could have not been studied in detail, although data at aggregated level would have suggested to include the sector, as only aggregate data was available. Other studies have shown, though, that R&D expenditures in this aggregated sector are attributable to ICT sub-sectors.

Estonia	65-67	Financial intermediation	1.6%	n.a.	3.4%
	15	Food and beverages	0.7%	217% (2000-2003)	2.8%
	27-29	Metal products, machinery	0.2%	161% (2000-2003)	2.5%
	36-37	Furniture, recycling	0.6%	196% (2000-2003)	1.5%
Hungary	24.4	Manufacture of pharmaceuticals, medicinal chemicals and botanic products	19.3%	-5% (2001-2003)	0.5%
	34.3	Manufacture of parts and accessories for motor vehicles and their engines	2.9%	114% (2001-2003)	0.8%
	33.1	Manufacture of medical instruments	2.7%	34% (2001-2003)	0.1%
	31.6	Manufacture of other electric equipment	3.5%	54% (2001-2003)	0.3%
Latvia	24	Manufacture of chemicals and chemical products	1.9%	50% (2001-2003)	0.6%
	74	Other business services	1.0%	68% (2001-2003)	3.0%
	17	Manufacture of textiles	0.03%	58% (2001-2003)	2.2%
	28	Manufacture of fabricated metal products	0.1%	1153% (2002-2003)	2.4%
Lithuania	24	Manufacture of chemicals and chemical products	5.3%	974% (2002-2003)	1.0%
	33	Manufacture of medical, precision and optical instruments, watches and clocks	0.8%	- <sup>3</sup>	1.3%
	29	Manufacture of machinery and equipment	0.9%	15% (2002-2003)	0.6%
	15	Manufacture of food products and beverages	0.3%	- <sup>4</sup>	3.5%
Malta	67.2, 66.1	Financial intermediation	0.4%	n.a.	1.4%
	29	Manufacture of machinery and equipment	0.9%	36% (2001-2003)	0.4%
	15	Food & Beverages	0.2%	n.a.	3.0%
	22	Printing	0.4%	n.a.	1.4%

<sup>3</sup> strong fluctuations, no trend

<sup>4</sup> strong fluctuations, no trend

Poland	29	Manufacture of machinery and equipment	1.3%	11% (2003-2004)	1.3%
	24.4	Manufacture of pharmaceuticals, medicinal chemicals and botanic products	n.a.	39% (2003-2004)	n.a.
	35.3	Manufacture of aircraft and spacecraft	2.0%	77% (2003-2004)	0.4%
	34	Manufacture of transport equipment (motor vehicles, trailers and semi-trailers)	1.3%	55% (2003-2004)	1.3%
Slovakia	27+ 28	Manufacture of base metals, fabricated metal products	0.1%	- <sup>5</sup>	3.5%
	34	Manufacture of motor vehicles and transport equipment	1.7%	-	2.2%
	25	Manufacture of rubber and plastic products	1.1%	10% (1998-2004)	1%
	24	Manufacture of chemicals, chemical products and man-made fibres	1.1%	- <sup>6</sup>	0.8%
Slovenia	31	Manufacture of Electrical Machinery and Apparatus	4.6%	18% (2001-2003)	1.3%
	24.4	Manufacture of Pharmaceuticals	8.8%	19% (2001-2003)	3.3%
	29	Manufacture of Machinery and Equipment	4.4%	22% (2001-2003)	2.2%
	33	Manufacture of medicine, precision and optical instruments	9.1%	27% (2001-2003)	0.7%

## 1.2. Data sources

For a general overview of comparable data on R&D investments at country and sectoral level, a screening of international databases was performed first. Thereby international statistical sources provided by OECD and EUROSTAT were taken into account.

The pre-screening showed that from the international sources only EUROSTAT provides a range of comparable data for the NMSs on aggregated level and some data on specific sectors.

The OECD provides another source, the Online Database OECD STAN Structural Analysis Database.<sup>7</sup> However, only Czech Republic and Poland from the NMSs are covered. Due to the lack of comparability and due to reliability restrictions in the OECD Database given interpolations and estimations of data, the OECD data are not included in this report.

<sup>5</sup> Unknown, because of the individual data protection. The company data suggest increase by about 20 % by 2004

<sup>6</sup> Unknown, because of the individual data protection

<sup>7</sup> This table presents comprehensive and internationally comparable time-series on industrial R&D expenditures in ISIC Revision 3 for 19 OECD countries, as well as total EU. Compatible with those used in other OECD databases, the industry list covers a number of service and technological sectors. Data covered are from 1987 onwards.

In parallel, national statistical sources were analysed that can provide additional comparable data to those available from international statistics. These national sources are based on R&D surveys and CIS surveys. A list of sources used can be found in the annex to the report.

### 1.3. Availability and reliability of data

The availability of data is documented in a matrix covering 24 indicators. The matrices for each country can be found as an annex to this report. The matrices cover information on all available sectoral data of the national economies and indicate for which years data are available. The sectors selected for the country studies are covered in addition to the general overview, to document some differences in availability per year and to reveal confidentiality of data.

Information given includes the *level of availability* of 24 indicators:

Two overall indicators:

1. Staff employed in R&D
2. R&D expenditure in NACE categories

Pattern of R&D expenditure according to different categorisations

In-house / outsourced:

3. in-house R&D expenditure
4. outsourced R&D expenditure

Tangible / intangible / human resources:

5. expenditure on acquisition of machinery/equipment
6. expenditure on acquisition of know-how
7. investment in human resources

Nature of private sector R&D activities

8. volume and share of basic research
9. volume and share of applied research
10. volume and share of experimental development
11. volume and share of new product development
12. volume and share of product improvement
13. volume and share of process improvement
14. volume and share of new service development

Source of funding of R&D activities

15. from within business enterprise sector
16. from abroad - total
17. from abroad - private sector
18. cash flow
19. company funds
20. loans
21. venture capital
22. grants
23. intellectual property licensing
24. public support

For these indicators the following information is given in an availability matrix for each country:

1. Data source  
The name of the source and of the publishing organisation is provided.
2. Level of availability of sectoral data  
The availability is given for aggregated data for whole economy for aggregated NACE categories (A-Q), for NACE 2 and 3 digit levels.
3. Years available

To provide information on the years for which data are available, one column, which is called "general availability", provides the range of available years that is covered in most cases. Fur-

thermore, for the sectors of the sectoral studies the years with available data are indicated to provide more specific information.

The following overall observations can be made regarding data availability:

- There is a gap in availability of data between EUROSTAT and the national statistical offices. As a general experience, data are available at more detailed sectoral level in the national offices than published at the EUROSTAT. As an exception to the rule, in the Hungarian case, some data are available from EUROSTAT which are not freely made available from the national statistic office.
- Availability of data differs between larger and smaller NMSs. In some sectors on NACE 3 level data are not published due to individual data protection in the case of limited number of enterprises involved (e.g. automotive industry in Slovakia).
- No general pattern of gaps can be found, however, the weakest category of indicators in terms of availability are indicators related to sources of funding of R&D activities (see indicators 15 to 24 above).

The reliability of sectoral data is considered to be high. All data sources are based on Frascati Manual or Oslo Manual (for CIS). Caveats are mainly due to changes in the method of R&D survey, but date back to the 1990s.

For some countries R&D data show dramatic changes in expenditure or employment figures from one year to another. This might be due to the fast structural changes that are taking place and the influence of FDI. Especially in smaller countries, FDI of multinational firms might be able to influence the characteristic of a sector within one year. Nevertheless, it is not clear if enterprises were always fully aware of standard definitions (of R&D, capital investment in R&D, etc) when filling in the surveys. In some cases, for instance, the investment in capital goods for R&D is not reflected in increasing R&D activities carried out by researchers. Thus, it must be doubted that R&D related capital investment without increases in R&D employment is a feasible way for sustainable capacity building.

## 2. Private R&D in selected sectors of NMSs

### 2.1. Cyprus

#### National Framework conditions

In May 2004 Cyprus joined the European Union and, therefore, has accelerated a number of developments in order to modernise its economic structure and adopt the *acquis communautaire*. Despite the small size of the country its income is higher than one would expect. This is due to the composition of its economy. Cyprus is taking advantage of its significant strategic location as the crossroads of three continents.

Research activities in Cyprus were limited up until the beginning of the 1990s. For the years 1991 and 1992 expenditure on R&D amounted to just 0.18% of Gross Domestic Product (GDP). Nevertheless, the R&D expenditure as a percentage of GDP remained low in 1999 reaching 0.3% of total GDP while an increase was recorded in 2004 reaching 0.4% of total GDP.

Total R&D expenditure in Cyprus in 2003 is estimated at 23.9 mio. C£ (41.4 mio EUR) (1 EUR = 0.577 Cyprus Pounds) which corresponds to 0.35% of the, GDP compared to 19,4 mio. C£ (33.6 mio EUR) or 0.32% of the GDP in 2002. Despite the increase of 23.1% observed in R&D expenditure in 2003, the share of GDP of Cyprus devoted to R&D activities continues to be low compared to other countries. During 2000, the rate of growth of the economy in real terms was 4.8% as compared to a 4.5% rate of economic growth in 1999. The main factors influencing this were a favourable external environment. The next table demonstrates the levels of development within the different and most important economic indicators in Cyprus.

EU Membership is now creating new opportunities for public initiatives in the area of innovation and development, using the resources of the structural funds. Cyprus is at a stage where there is a wish to diversify its policies and turn its major activities towards different sectors of the economy, other than tourism, financial services and shipping. The expansion of basic infrastructures, the development of human capital and the promotion of equal opportunities to both female and male researchers as well as the protection of the environment and the advancement of quality of life for citizens are considered to be the leading priorities towards promoting competitiveness from the Cypriot government.

#### Construction Sector (NACE F)

The construction sector is a significant contributor to the country's economy, especially in the last few years. In the southern part of the island the construction industry was in decline in real terms for several years during the second half of the 1990s. In 2000, construction accounted for 7.1% of gross value added and 8.2% of total employment.

There was further decline in the sector by 2% in 2000, although leading indicators of future performance point out that the sector has entered a recovery phase and that this downward trend will be reversed.

In 2004, the sector continued to register an upwards trend, recording a positive rate of growth in its value added in real terms. In 2004, the real growth was 5.8% compared to 7.1% in 2003 and 5.5% in 2002. This is attributed mostly to the significant increase in the construction of residential buildings, an industry branch which is not considered to be R&D intensive. The value of new construction at current market prices comprised 89.8% of the total gross output in the construction industry in 2004.

As far as R&D activities are concerned, this sector does not contribute significantly to the development of the economy in this field. According to statistics, the main type of research un-

undertaken in this sector is basic research which records approximately 50% of this sector R&D activity in 2003.

As far as employment is concerned, in the construction sector the number of persons employed increased from 29,518 persons in 2003 to 29,970 in 2004 and accounted for 9.3% of the gainfully employed population for the production of GDP. The number of persons registered as unemployed is increased from 685 persons in 2003 to 780 in 2004. At the same time, the construction sector's labour costs during 2004, continued to rise registering an increase of 4% compared to 5.8% in 2003 and 5% in 2002. The overall price index of construction materials increased by 8.2% compared to 4.6% in 2003<sup>8</sup>.

According to statistics, the researchers in the construction sector were 3 (in head count), which represents approximately 1.17% of the total number of researchers in the private sector in 2003. Additionally, the total number of researchers in FTE was 0.5, which represents about 0.5% of the total number of researchers in this sector in Cyprus.

For the first quarter of 2005, the volume of production in the construction sector increased by 1.9% while the increase in the first quarter of 2004 was about 3.2% and 4.5% in total in 2004. This positive development continued up until recently according to a list of specific indicators that have been analysed in relation to investment actions in construction projects.

According to the case study in the construction sector, R&D activities were not undertaken by a single R&D department. In more detail, R&D activities are not considered to be part of every day work routine in such companies. Based on the case study performed within this project, the goals set are not long-term and they don't affect much the production and innovation processes. The main focus of their R&D activities is not in the "innovative products development" but mainly in the processes and methods used in their work.

### **Manufacture of chemicals and chemical products (NACE 24)**

The manufacturing sector of chemicals and chemical products is being faced with difficulties, having to cope with a fall in the growth of production, exports and employment. This has been due to increased and intensive competitiveness, both abroad and in the local market. By 2002 the sector accounted for about 10% of GDP and almost 12% of the total employment in the country. However, it continues to be an important sector for the economy, accounting for approximately 12% of GDP and 16% of employment. Exports of manufactured products in 2003, compared to 1973 figures (15 mio. C£), recorded a large increase and reached about 191.6 mio. C£ (331.8 mio. EUR).

In the first semester of 2005 there was a decrease in the production volume by 1.6%, while in the same period in 2004 the production volume was increased by 2.4%. This decline was due to the low internal demand (owed to the increased imports). Exports of manufactured products constitute the bulk of Cyprus' domestic exports and represented 63.8% of total exports in 2002.<sup>9</sup>

The chemical industry production in Cyprus is characterised by very heterogeneous products. They range from basic chemicals to fine chemicals and from paints through detergents to polymers. The sector has both strong and weak points.

Researchers in this sector are mainly stemming from natural sciences. On the one hand, the total number of researchers was 61 (in head count) in 2003, which represents approximately 24% of the total number of researchers in the private sector in 2003 and about 50% of researchers in the manufacturing industry. On the other hand, the total number of researchers in FTE was 35.7 in 2003, figure which represents 34.7% of the total number of researchers in the private sector in Cyprus and about 67% of researchers in the manufacturing industry.

<sup>8</sup> Cyprus Statistics, Construction and Housing Statistics, 2004, Republic of Cyprus

<sup>9</sup> Source: <http://countrystudies.us/cyprus>

According to the Cypriot Statistical office data, there are 55 enterprises producing chemicals and chemical products and the average number of all employees per enterprise for this sector has been recorded to 17.7%. The R&D expenditure related to personnel reached the 1.3 mio. EUR in 2003 while the capital expenditure has reached the amount of 573 thousand EUR. According to statistics, the main type of research activity that has been observed is mainly experimental research, while applied and basic research comes next.

The manufacturing sector exhibited a 4% increase in real terms, although its contribution to GDP fell to 20% from 20.7% in 1999. The volume of exports of manufactured goods increased significantly by 11.9% as a result of increased external demand.

According to the case study, the company interviewed has experimented and succeeded with new products. Benefiting from advancements in technology, it has also managed to specialise in a variety of products. A distinctive feature of the company and of the sector in general is the efforts made in introducing novel ideas and products.

### **Manufacture of machinery and equipment (NACE 29)**

In 2001, manufacturing of machinery and equipment was the second largest manufacturing NACE division in value added terms, following the manufacturing of food products and beverages. In 2002 the machinery and equipment manufacturing sector was the third largest following the manufacture of food and beverages and that of chemicals and chemical products. With 164.7 bn. EUR of value added generated in the EU-25, the sector accounted for 9.4% of total industrial value added.

In 2002, there were 3.5 mio people employed in this sector in the EU-25. This was equivalent to 9.8% of the overall industrial workforce. In terms of headcount, the people employed in this sector were 1314 in Cyprus. The sector is male dominated, as the male employees registered in 2004 were 77.8% of the total. In 2003, there were 248 enterprises registered in the sector. The capital expenditure in R&D was about 72 thousand EUR in 2003 while the labour costs in R&D in this sector have been 103 thousand EUR.

Given the importance of the manufacturing sector as a whole in increasing the overall R&D expenditure, experimental research was the basic type of research activity undertaken (with a total expenditure of 103 thousand EUR), while applied research followed registering an amount of 54 thousand EUR.

In 2003, the total number of researchers was 13 (in head count). This represents approximately 5% of the total number of researchers in the private sector in 2003 and about 10% of researchers in the manufacturing industry. On the other hand, the total number of researchers in terms of FTE was 2.9 in 2003, representing 2.8% of the total number of researchers in the private sector in Cyprus and about 5.5% of researchers in the manufacturing industry.

### **Financial Intermediation (NACE J65)**

The 'newness' of the financial service sector, the recurring crises and the low level of confidence of depositors largely account for the relatively small size of the financial sector in the transition economies. Although it was expected to find some interesting evidence on R&D in the financial sector, the sectoral study showed that hardly any significant activity can be detected.

The company that was contacted for the case study mentioned that there is no R&D unit, but all staff members are involved in research concerning new products and services. Official statistics report 5 employees in R&D (full time equivalent) in 2003. Expenditure of the private sector was reported to be 238 thousand EUR which were mainly spent for labour costs. Another 121 thousand EUR were contributed by the EU by means of the 5<sup>th</sup> Framework Programme.

The financial services sector contributes around 20% of GDP. This figure has increased by 95.9% since 1995. However, there has been little or no growth since 2000. In 2001, the financial intermediation sector comprised 7.3% of total gross value added.

The financial intermediation sector in Cyprus uses applied research as its main type of research activity with 121,500 EUR while experimental research comes second and no basic research is undertaken.

The corporate bond market is rather small, while the government bond market is of limited importance, due to the low level of government debt. For example, in 2003 the general government debt of the ten acceding countries amounted to 42.4% of GDP on average, as compared with 64% in EU-15. Cyprus at 60.3% of GDP and Malta at 66.4% of GDP, displayed relatively high levels, approaching the EU average.

Financial markets of New Member States are small in both absolute and relative terms. While total financial intermediation relative to GDP is about 300% in the Euro zone and in the EU, it is a mere 85% of GDP in the New Member States and especially low in the Baltics with 36% of GDP. Only the small financial markets of Cyprus and Malta come somewhat closer to the EU average of financial intermediation, partly due to their function as offshore financial centres. In Cyprus total bank assets including domestic and foreign assets with 388% of GDP are larger than total domestic financial intermediation with 267% of GDP<sup>10</sup>. The development of the financial intermediation sector is significant due to its remarkable increased demand. Researchers are more focused in natural sciences which makes this sector more likeable.

Financial intermediation regarded by entrepreneurs as more male dominated than employees regard it. On the one hand, the total number of researchers was 11 (in head count) in 2003, which represents approximately 4.2% of the total number of researchers in the private financial intermediation sector in 2003. On the other hand, the total number of researchers in FTE was 5.1 in 2003, figure which represents 5% of the total number of researchers in this sector in Cyprus.

## **2.2. Czech Republic**

### **National Framework conditions**

Total R&D expenditures (GERD) have been increasing in the Czech Republic since 1995 and in 2004 the total amount exceeded 35 000 mio. CZK (1.1 bn. EUR). The share of total R&D expenditures in GDP was 1.3 % in 2004.

Private sector represents the most important source of R&D financing in the Czech Republic. The share of private funds has been slightly increasing since 2000 and it reached 0.7 % of GDP in 2004 (more than 700 mio. EUR). More than 90% of total BERD is spent in the business enterprise sector. Low share of private resources in R&D expenditures of the government and the higher-education sectors indicates that private companies insufficiently utilise public research institutions and universities. The number of researchers in the private sector has been growing since 2000 and reached 7,297 researchers (FTE) in 2004. About 50 % of researchers are in the manufacturing industry (3,654 researchers) and their number has been slightly increasing since 2000.

Public funds are stagnating and their share amounted to 0.53 % of GDP in 2004. Funding of industrial research and development is administered by the Ministry of Industry and Trade. Some of the programmes (e.g. Research Centres and Tandem) are focused on collaborative (joint) research, where only common projects of the industry and academia are eligible.

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<sup>10</sup> Breuss, F., Fink, G. and Haiss, P., How well prepared are the New Member States for the European Monetary Union?, paper for the special issue on "Enlargement of the European Monetary Union" by Dominick Salvatore(ed.) of the *Journal of Policy Modeling*, Summer 2004.

The Ministry of Industry and Trade has also launched several programmes supporting industrial development, innovation and growth of competitiveness of SMEs within the Operational Programme Industry and Enterprise (e.g. INOVACE - Innovation, PROSPERITA – Prosperity and ROZVOJ – Development).

The Czech government introduced a system of investment incentives for foreign and domestic investors in 1998, which is fully compatible with relevant regulation of the EU. The system of investment incentives has a significantly positive influence on the Czech economy, encourages economic recovery (including enhancement of research infrastructure) and helps the national active employment policy.

The Czech government has also introduced an indirect support of R&D through a new tax regulation which has been in force since 2005. This modification of the revenue act enables business entities to deduct expenses spent on R&D from their tax base. R&D related costs may be applied twice in the accounting – first as expenses as such and then separately as an amount to be deducted from the tax base before taxation.

The infrastructure of the industrial R&D was seriously affected by the privatisation process in the 1990s. Its size decreased by more than a half - in some branches even more - and the profile of individual R&D units has been changed in favour of non-research activities. The situation in private R&D has been becoming stable recently and research infrastructure was effectively profiled according to capacities of the Czech science system.

#### **Manufacture of motor vehicles, trailers and semi-trailers (NACE 34)**

The business enterprise R&D expenditures in NACE 34 - Manufacture of motor vehicles, trailers and semi-trailers - amounted to about 180 mio. EUR in 2004, considerably exceeding R&D expenditures in other sectors of the manufacturing industry in the Czech Republic. R&D expenditures in this sector increased more than three times from 1996 to 2004 and have been relatively stable since 2000. The share of R&D expenditures of the automotive industry in the total BERD exceeds 26%, which is more than 42% of the R&D expenditures in the manufacturing industry.

Number of researchers has been gradually increasing since 1991. The total number of researchers was 982 (FTE) in 2004, which represents more than 13% of the total number of researchers in the private sector in the Czech Republic and about 27% of researchers in the manufacturing industry.

The automotive industry is also a sector with the largest share of the gross value added in the manufacturing industry and its share in the national gross value added has grown to 2.7 % (more than 2 bn. EUR) in 2004. Moreover, main production indicators like receipts from sales of own products and services, number of employees, value added and labour productivity have been permanently increasing since 2000 (for instance, receipts in automotive industry have increased by 50% in the last five years).

The automotive industry is one step ahead in comparison with other branches of the Czech industry. The sector benefits from massive FDIs, which have supranational character. FDIs have helped to increase the labour productivity and quality while it maintains favourable labour costs and output price. The recent growth of R&D expenditures in this sector can be also attributed to these FDIs.

Economically strong companies tend to have their own R&D capacities (e.g. Skoda Auto, Karosa or Autopal). There are also several private R&D institutes specialised in automotive engineering in the Czech Republic. Public sector R&D capacities for the NACE 34 sector are mostly at technical universities, which are located in Prague, Brno, Pilsen and Ostrava. These universities cooperate with enterprises in particular research projects and their graduates are often employed by industrial companies in the region.

Generally, the automotive industry sector as a whole is under increasing price competition. Vehicle manufacturers are permanently trying to decrease their costs due to the significant influence of globalisation. The Czech automotive industry is exposed to a pressure on quality, product range and price and must be more flexible in terms of the fast changing market situa-

tion. Any change in production is related to investment and therefore it is very important to consider every step towards innovation. A very competitive domestic market also forces local automotive suppliers to be flexible and “customer friendly”.

The Czech Republic has become an important manufacturer of cars in Central Europe. The annual manufacture is assumed to be 800 thousand cars in 2006, from which 700 thousand cars will be exported. Skoda Auto Inc. as the most important exporter participates in the total export of the Czech Republic by more than 9%. One may add Toyota-Peugeot-Citroën Automobile (TPCA) to these figures, and in the foreseen future the two automobile plants will represent 12-15% of the total export of the Czech Republic.

### **Manufacture of chemicals and chemical products (NACE 24)**

Manufacture of chemicals and chemical products is a sector with the second highest business enterprise R&D expenditures in the manufacturing industry. The R&D expenditures reached 50 mio. EUR in 2004, covering more than 10 % of R&D expenditures in the manufacturing industry and 7 % of the total BERD. R&D expenditures were decreasing in the first half of the 1990s due to the privatisation, however, during the period 1995 – 2004 the R&D expenditures in this sector doubled and a considerable increase was evident particularly in 2004. The business enterprise R&D expenditures in the pharmaceutical industry (NACE 24.4) amounted to almost 62% of R&D expenditures in NACE 24 and the share of NACE 24.4 in R&D expenditures increased significantly in recent years (49% in 2003).

Number of researchers decreased in the second half of the 1990s. However, the number of researchers started to grow again in 2000, reaching 549 researchers (FTE) in 2004, which represents more than 7% of the total number of researchers in the private sector and 15% of researchers in the manufacturing industry. This development can be explained by restructuring of the Czech chemical industry and the overall improvement of the economic performance during the last years.

The share of this sector in the national gross value added reached 1.4% in 2004 (more than 1.1 bn. EUR). A significant part of this gross value added is produced in the sub-sector 24.1 – Manufacture of basic chemicals (almost 60%) and NACE 24.4 – Manufacture of pharmaceuticals (22.6%).

Privatisation by a strategic partner has not been so frequent and successful in this sector compared to the automotive industry (e.g. Skoda Auto). Privatisation of the most important group Unipetrol (a shareholder of producers of hydrocarbons, petrochemicals and other chemicals) has been postponed and is not finished yet. A part of the “traditional” Czech chemical industry suffered from the unsuccessful privatisation of Chemapol and hence lost its innovation dynamics. Some companies have even been re-privatised (Chemicke zavody Sokolov – Eastman, now Hexion Specialty Chemicals or Moravske chemicke zavody, now BorsodChem).

In some cases established company research facilities have not been fully utilised. Sometimes companies placed their R&D facilities in daughter companies and now they outsource the necessary R&D (in a reduced volume). The (former) research institutions try to compensate for the lacking demand for R&D by working for third parties including foreign companies. Many of them developed activities in related sectors (services, production of valuable chemical specialties etc.). Public R&D capacities for the NACE 24 sector are mostly at technical universities, which are located in Prague, Pardubice and Brno. These universities cooperate with enterprises in particular research projects, which are in some cases co-funded from the state budget. There are comparatively strong public R&D capacities in the Czech Academy of Sciences, which offer a big potential for further utilisation in more advanced production of chemical products and in chemical technologies.

The whole picture should be completed by some very successful cases of privatisation, like Zentiva or IVAX. Those companies have built systematically their R&D capacities and now base their further growth on innovation. Besides these companies there are a few small companies (Aroma, Interpharma, Synthon, NeraPharm) and spin offs (Katchem) which are

strongly innovative and in many cases collaborate with academic institutions in various collaborative (joint) R&D programmes.

### **Manufacture of electrical machinery and apparatus n.e.c. (NACE 31)**

Manufacture of electrical machinery and apparatus is a sector with very high increase of business enterprise R&D expenditures in the Czech Republic in recent years. R&D expenditures were rapidly decreasing in the first half of the 1990s due to the privatisation, however, in 1998 R&D expenditures started to grow again and increased four times from 1997 to 2004 reaching 25 mio. EUR in 2004 (5.7% of the total BERD, 3.5% of the R&D expenditures in the manufacturing industry). Considerable increase is evident in 2002 and during the last four years R&D expenditures doubled. R&D expenditures have been growing faster in the NACE 31 sector than in the whole manufacturing industry and their share in the manufacturing industry as well as in the total BERD has been increasing.

The highest R&D expenditures are in the NACE 31.6 - Manufacture of electrical equipment, which includes production of electrical equipment for motors and cars (NACE 31.61), NACE 31.1 – Manufacture of electric motors, generators, and transformers, and NACE 31.2 – Manufacture of electricity distribution and control apparatus.

The number of researchers in the NACE 31 sector has been generally growing since 1994. A slight decrease in the number of researchers in 1998 and 1999 corresponds to a fall in the growth of R&D expenditures in this sector between 1999 and 2001. A significant increase in the number of researchers is evident in 2002 and from 2001 to 2004 the number of researchers in NACE 31 increased by 60% reaching 256 researchers in 2004, which is about 3.5% of the total number of researchers in the private sector and about 7% of researchers in the manufacturing industry.

The share of the NACE 31 sector in the national gross value added has grown to 1.8% (1.6 bn. EUR) in 2004. The number of employees has been stable in this sector since 2000, however, receipts from sales of own products and services, value added, and labour productivity have been growing faster than those in the manufacturing industry. According to the sales, NACE 31.6 – Manufacture of electrical equipment, NACE 31.2 – Manufacture of electricity distribution and control apparatus, and NACE 31.1 - Manufacture of electric motors, generators and transformers are the most important sub-sectors. The most important sub-sector, NACE 31.6, reported the highest growth of sales in 2004, which can be attributed to the expansion of the automotive industry (NACE 34). This subsector also creates the highest value added in the entire NACE 31.

Privatisation in the early 1990s negatively influenced performance of this sector and resulted also in a reduction of private R&D activities. Nowadays this sector benefits from FDI, which have been positively affecting rapid restoration and further development of R&D activities in this sector. The sector also benefits from the development of the automotive industry (Skoda-Auto and recently Toyota-Peugeot-Citroen Automobile).

Economically strong companies have usually their own R&D capacities (e.g. Siemens, ABB, and SKODA) in the Czech Republic. There are also several private R&D institutes specialised in electrical engineering in the Czech Republic. Public sector R&D capacities for the NACE 31 sector are mostly at technical universities, which are located in Prague, Brno, Pilsen and Ostrava. These universities cooperate with enterprises in research projects and their graduates are often employed in industrial companies in the region.

The NACE 31 sector has been attractive for foreign companies to invest in due to the quality and still a relatively cheap labour force. However, the lack of qualified technical workers (especially young technicians) in some regions of the Czech Republic can negatively influence future development of this industry and building up new production and development capacities.

### **Manufacture of rubber and plastic products (NACE 25)**

Manufacture of rubber and plastics products belongs to the most dynamic industries in the Czech manufacturing sector since the second half of the 1990s. Its position in the manufacturing industries has significantly improved and this enormous increase has resulted from its close relation to the rapidly increasing automotive, electrical, food as well as building industry that create the core of the Czech industrial structure.

R&D expenditures in the NACE 25 are still quite low (more than 10 mio. EUR in 2004, which is about 1.5% of the total BERD and 2.4% of the R&D expenditures in the manufacturing industry). However, for the next development of this sector it is positive that R&D expenditures increased almost twice from 2001 to 2004. The increase of R&D expenditures in this sector was higher than in the whole manufacturing industry and resulted in a strengthened position of this sector in the R&D structure. Significant amount of R&D expenditures in 1998 was caused by a privatisation of some key producers. Nevertheless, the share of R&D expenditures in the sector is still lower in comparison with its shares in employment, sales and value added.

The number of researchers stagnated in the last 5 years and is lower in comparison with the year 1995 (123 researchers in 1995, 83 researchers in 2004). The number of researchers in 2004 represents 1.1% of the total number of researchers in the private sector and 2.3% of researchers in the manufacturing industry.

The share of the NACE 25 sector in the national gross value added has grown to 1.6% (more than 1.2 bn. EUR) in 2004. The value added in this sector increased by more than 90% from 2000 to 2004 and also the number of employees, receipts from sales of own products and services and labour productivity have been permanently increasing since 2000.

Recent dynamic growth of the rubber and plastics industry and its integration in global suppliers' networks was followed by restructuring of enterprises and product modernisation. As a result of a successful privatisation and establishment of new production units the expenditures on R&D activities have increased since 2001.

R&D in manufacture of rubber and plastics products has a long tradition in the Czech Republic. R&D activities in the NACE 25 are mainly driven by foreign companies operating in the Czech market, enormous growth in production of automotive and electrical machinery and a growing foreign demand. The largest producers in the NACE 25 tend to have their own R&D capacities (e.g. MITAS, RUBENA, GUMOTEX or Kaucuk). Private R&D is also provided by many private R&D institutions, transformed R&D institutions (formerly in state ownership) and newly established organisations. Cooperation between universities and firms consists in a joint involvement in specific research projects, memberships in scientific and examining commissions, students expert practice, etc.

### **2.3. Estonia**

According to the projections of the strategy document *Knowledge-Based Estonia, Research and Development Strategy 2002-2006* total R&D investments were expected to reach 1.5% of GDP by the year 2006 with the government contributing a significant share of this as the private sector slowly increases its investment levels. The actual investment into R&D in 2006 is about two-thirds of what was expected (in 2004 total investments into R&D amounted to 0.9% of GDP)<sup>11</sup>.

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<sup>11</sup> Two studies of the Statistical Office of Estonia are used as main data sources. Although detailed statistical information is sometimes not released due to individual data protection, the regular survey on business sector on R&D and the Community Innovation Survey (CIS3 for 1998-2000 and CIS4 for 2002-2004) are used here. Also, some major fluctuations can be observed in time series that could be explained by the addition of just some R&D reporting companies, although the latter could be due to administrative changes in reporting and not to changes in company activities. Extensive secondary sources were also used in preparing the report. In addition, to get a better and deeper understanding of the patterns and dynamics of R&D activities in private firms, two case studies were prepared based on semi-structured interviews with representatives of the companies.

Personnel engaged in business sector R&D has grown more than twice in Estonia over 1998-2004. Two sectors – manufacture of electrical and optical equipment and computer and related activities – employ more than half of the total R&D personnel and spend one third of the total R&D expenditures. These sectors were not in the focus of the current study, although, based on some other studies carried out on these sectors, one could hesitate if such rapid increasing indicators are in accordance with reality.

In addition, almost no studies have been carried out which measure the impact of public R&D subsidies on economic performance. The first such wide-scale assessment is going on at the moment. Therefore no reference can be made in this respect in this report.

### **National Framework Conditions**

All in all, the current situation is partially caused by the science, technology and innovation (STI) policies of the past and reinforced with the current policies. Namely, Estonian reforms in the field of STI have even been characterized as "shock without therapy" approaches leading to a loss of lot of R&D supply channels as well as absorptive capacities. There have been no selective FDI-policies implemented in Estonia and Estonia had no industrial policy, too. State financing of the Estonian innovation system has been and is, to a great extent, targeted at the promotion of commercialisation and other economic uses of research and knowledge. It is concentrated in universities and other R&D institutions, i.e. it is intended to finance researchers and knowledge transfer into the enterprise sector.

As a consequence, relatively high economic growth (both GDP and export growth) is taking place, but in the course of fast export- and consumption-based growth, the volume of technology and skills in the economy has decreased. Many important economic sectors are of subcontracting nature and local clustering (contacts with other companies, educational and R&D institutions) - positive feedback mechanisms - are essentially missing. As Estonia is loosing its attractive position as cheap production place, higher value added production and related R&D is seen, in rhetoric, as a possible alternative. However, due to path dependencies it is by no means easy to achieve.

### **Financial intermediation (NACE 65-67)**

Out of the four sectors studied the most successful one is financial intermediation. The share of the sector in the national GDP was 3.4% (273 mio. EUR) in 2003. The private R&D expenditures amounted to 4.3 mio. EUR in 2004. The share of R&D expenditures of the financial intermediation in the total BERD exceeds 11%.

The number of researchers has also been increasing in 2003-2004. The total number of researchers was 81 (FTE) in 2004, which represents more than 7.8% of the total number of researchers in the private sector in 2004.

The share of innovative companies has been very high, most of the technological innovations are arguably ICT-related. R&D employees are mainly ICT experts. The financial intermediation market is rather consolidated and all of the main players are active in R&D and ICT-innovations. Some R&D intensive collaborative efforts have been noted.

The currently very high level of R&D and innovation in the Estonian financial intermediation sector (and especially in the banking sector) can be explained by the following factors: high level of ICT competence as Soviet legacy, the emergence of modern banking sector in Estonia overlapped with emergence of Internet-based ICT-paradigm, and an explosive use of the Internet in Estonia. The consolidated structure enabled a few key players to invest remarkably and an on-going expansion of the financial intermediation sector due to favourable circumstances in the market boosted the development.

### **Food and beverages (NACE 15)**

The food industry is the biggest manufacturing industry in Estonia. The share of the sector in the national GDP was 2.8% (205 mio. EUR) in 2003. The two most important fields in the Estonian food sector have traditionally been dairy products and fish industry.

The private R&D expenditures amounted to 1.2 mio. EUR in 2004, private R&D expenditures in this sector increased 3 times from 2000 to 2004. The share of R&D expenditures of the food and beverages industry in the total BERD exceeds 3%, which is more than 7% of the private R&D expenditures in the manufacturing industry.

The number of researchers has been decreasing in 2000-2004. The total number of researchers was 16 (FTE) in 2004, which represents more than 1.5% of the total number of researchers in the private sector in 2004 and about 3.6% of researchers in the manufacturing industry.

The most relevant factors which have influenced the Estonian food industry's structure in the years 1990 to 2004 are mostly state enforced food trade policy and little agricultural assistance policy in the beginning of the 1990s. In addition, Russian crisis hit very hardly on the Estonian food sector and additional pressure has been exerted on the Estonian food industry by the fulfilment of EU requirements.

When looking at the ownership structure of the Estonian food sector, it becomes evident that besides dairy production and fishing industry, over half of the whole industry belongs to foreign investors operating in Estonia. Such ownership structure is the main reason why only the first two sectors lean on the co-operation with Estonian R&D establishments. Other industries, operating under FDI have indicated unwillingness to carry out R&D in Estonia.

Although food enterprises are reported as being more innovative than the average of manufacturing industry, R&D expenditures as well as employment related to R&D are quite modest. Over a longer time series even decreases can be observed. There is very little research-intensive product development carried out in Estonia. Most innovations are related to the fulfilment of EU sanitation requirements. Product developments have been mainly related to widening the product mix, new packaging and marketing.

### **Manufacture of metal products and machinery (NACE 27-29)**

The metal and machinery industry developed very fast during the re-independence period. Production of the metal industry grew tenfold in ten years, thanks to exports. But also domestic demand (in machinery and equipment and construction sectors) increased significantly.

The share of the sector in the national GDP was 2.5% (183 mio. EUR) in 2003. The private R&D expenditures amounted to 1.1 mio. EUR in 2004, private R&D expenditures in this sector increased 5 times from 1999 to 2004. The share of R&D expenditures of the metal products and machinery industry in the total BERD exceeds 3%, which is more than 7% of the private R&D expenditures in the manufacturing industry.

The number of researchers has been increasing in 2000-2004. The total number of researchers was 65 (FTE) in 2004, which represents more than 5.2% of the total number of researchers in the private sector in 2004 and about 12.6% of researchers in the manufacturing industry.

The development of the machinery industry is mainly rooted in foreign markets, as most of the production is exported. In 2004, the machinery sector experienced the highest growth in R&D expenditures and R&D personnel of all sectors.

The shortage of skilled labour has been becoming a major obstacle for further development of the sector. Many engineers retired or are on the verge of retiring by now. Finding new specialists to replace these people have been a painful process for the companies.

The share of new products in metal and metal products industry has been rather modest in terms of turnover and current competitive advantages are based on lower labour costs. A further characteristic of the sector is the fact that only one company has received public funding for a R&D project. The companies in the machine building sector tend to be more innovative than other sub-sectors. These companies co-operate with R&D institutions and apply for public funding. Most of these projects are set up to develop machines for forestry, agricultural and communes.

### **Manufacture of furniture and recycling (NACE 36, 37)**

The share of the sector in the national GDP was 1.5% (109 mio. EUR) in 2003. The private R&D expenditures amounted to 0.4 mio. EUR in 2004, private R&D expenditures in this sector increased 2 times from 2000 to 2004. The share of R&D expenditures of the furniture and other manufacturing industry in the total BERD exceeds 0.9%, which is more than 2% of the private R&D expenditures in the manufacturing industry.

The number of researchers has been decreasing in 2001-2004. The total number of researchers was 15 (FTE) in 2004, which represents more than 1.4% of the total number of researchers in the private sector in 2004 and about 3.4% of researchers in the manufacturing industry.

The share of the furniture sector in R&D expenditures of the whole manufacturing industry (2%) is considerable smaller than its contribution to industrial production or value added (9%). Thus, production volumes have grown rapidly and the existing competitive advantages are based on low labour costs and other favourable cost structures. The availability of domestic resources (production of sawn wood and wood-based panels), the closeness of main target markets, and availability of good transport capabilities (e.g. ports) are the main strengths of the Estonian furniture industry.

Most of the innovative activities of the companies are related to process innovations (e.g. computer-aided manufacturing systems), marketing innovations (advertisements, large companies investing into distribution channels), but the share of product innovations is lower. Concerning the latter, Estonian furniture firms are generally reactive to the design setting of competitors and only 20 firms in furniture industry employ designers; among them 5 companies are exporters.

The role of government is seen in directing the R&D policy towards traditional industrial sectors (including furniture), but also improving the educational system and promoting cooperative arrangements.

## **2.4. Hungary**

### **National Framework conditions**

Given the importance of sectoral characteristics, only a few overall conclusions can be drawn here. First, business R&D expenditures are very low in Hungary: 0.3% of GDP (in 2004), which is less than one third of the EU-25 average. Second, BERD is highly concentrated: pharmaceuticals industry accounts for more than one third of the total (34.4% in 2004). Case study evidence suggests that BERD is concentrated in terms of size and ownership: the bulk of BERD is spent by large, foreign-owned companies.<sup>12</sup>

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<sup>12</sup> These data at a national or sectoral level are not publicly available, either – but can be purchased.

The four sectoral case studies confirm the dominant role of foreign-owned firms in RTDI activities, too. Foreign-owned firms tend to be large, and thus the decisive share of BERD is performed by large enterprises. Using EUROSTAT data, the share of large firms (with 250 or more employees) was 96% of total R&D expenditures (2003), and 78% of total R&D personnel in manufacturing industry (2004).

#### **Manufacture of pharmaceuticals (NACE 24.4)**

The pharmaceuticals industry has been one of the best performing industries considering its overall performance and the specified R&D indicators since the transition of the Hungarian economy. Between 2001 and 2003, R&D expenditure in the pharmaceuticals industry increased by 20 percent/year on average and R&D intensity averaged around 11% and 20% in terms of sales revenues and sectoral GDP. This is by far the highest R&D intensity value with respect to both indicators in the Hungarian manufacturing industry.

The share of pharmaceuticals in the national GDP has grown to 0.5% by 2003, thanks to a healthy growth in its production value (from 840 mio. EUR in 1999 to 1537 mio. EUR in 2003).

The private R&D expenditures in NACE 24.4 amounted to 82.6 mio. EUR in 2004, up from 43.7 mio. EUR in 1998. The share of R&D expenditures of pharmaceuticals industry in the total BERD is close to 28% and exceeds 34% of the private R&D expenditures in the manufacturing industry.

The number of researchers has been fluctuating around 1600-1700 since 1998. The total number of researchers was 1771 (head counts) in 2004, which represents around 20% of the total number of researchers in the private sector.

According to the major conclusions of the sectoral case studies, pharmaceuticals industry is the most R&D intensive sector in Hungary, which is in line with the global trends of this sector. The sectoral research system has been radically restructured during the past fifteen years as foreign pharmaceuticals manufacturers became majority owners in most companies, and they pursue global R&D strategies. In Hungary, they focus on the development of generic drugs. Thus, the number of research projects has decreased, but the allocation of R&D expenditures became more efficient.

FDI became a major determinant of R&D at the Hungarian companies. R&D plays an increasingly important role in maintaining and improving the companies' competitive positions. It is even more so in the case of pharmaceutical companies, whose long-term competitiveness depends on their ability to innovate and develop original molecules. Companies mainly specialising in the production of generics cannot maintain a competitive edge over producers from the Far East, and recently introduced EU environmental protection regulations also pose difficulties for their operations.

The foreign investors have significantly restructured the R&D system of their Hungarian affiliates. In most cases, R&D at the Hungarian companies became a sub-system in the global R&D programme of the parent companies, which determines on the global scale what type of research is to be performed by the Hungarian companies. As a result, research at the Hungarian manufacturers is restricted to areas specified in the global R&D strategy, and thus original research performed only in specific areas. New product development of the domestic companies decreased, as well as the number of patent applications for original products, which is also due to the introduction of product patents (replacing process patents). The transition from the process-patent to a product-patent system meant that Hungarian manufacturers had to introduce a dramatically new approach to research. The range of products has also decreased in many cases, because the parent company has replaced Hungarian products by its own products. Another visible effect is that the cooperation between domestic companies and universities became more limited, and it is performed mainly in the field of developing analytical tests.

### **Manufacture of parts and accessories for motor vehicles and their engines (NACE 34.3) and Manufacture of electrical equipment for engines and vehicles (NACE 31.61)**

Two sectors, NACE 34.3 and NACE 31.61 are analysed together, because they are closely related: although statistically they belong to different sectors, in essence both of them are parts of automotive industry, broadly defined. One of them has been selected for this project because of its high R&D-intensity (in the Hungarian context), that is, manufacture of parts and accessories for motor vehicles and their engines (NACE 34.3). The other one has been chosen due to its fast growing R&D-intensity, namely, manufacture of electrical equipment (NACE 31.6). This latter sector covers the sub-sector called manufacture of electrical equipment for engines and vehicles (NACE 31.61)

The share of the automotive components industry in the national GDP has grown to 0.8% by 2003, thanks to a healthy growth in its production value (from 1000 mio. EUR in 1998 to 2049 mio. EUR in 2003).

The private R&D expenditures in NACE 34.3 amounted to 12.5 mio. EUR in 2004, up from 4.2 mio. EUR in 1998. The share of R&D expenditures of the automotive components industry in the total BERD amounts to 4.2%, that is, 5.2% of the private R&D expenditures in the manufacturing industry.

The number of researchers has more than doubled since 1998. The total number of researchers was 367 (head counts) in 2004, which represents around 4% of the total number of researchers in the private sector.

The share of the other electric equipment industry – essentially electrical equipment for engines and vehicles – in the national GDP has reached to 0.3% by 2003, thanks to a healthy growth in its production value (from 317 mio. EUR in 1998 to 1,092 mio. EUR in 2003).

The private R&D expenditures in NACE 31.6 amounted to 2.9 mio. EUR in 2004, up from 0.4 mio. EUR in 1998. The share of R&D expenditures of the electrical automotive components industry in the total BERD amounts to 1%, that is, 1.2% of the private R&D expenditures in the manufacturing industry.

The number of researchers has increased 2.5 times since 1998. The total number of researchers was 85 (head counts) in 2004, which represents around 1% of the total number of researchers in the private sector.

Automotive industry has been traditionally less R&D intensive. Yet, innovation, R&D and engineering skills are becoming decisive factors of success for automotive firms, given the fierce competition in this market. The challenges for R&D and innovation are improved products in terms of safety, comfort, and fuel efficiency. These product innovations are assisted, and, in the meantime, also pressed, by ever faster technological changes. Hungarian engineers have been endowed with these skills and knowledge. Results of the interviews suggest emerging co-operation between automotive firms on the one hand, and university departments as well as other R&D units on the other. More recently, some foreign investors have also realised the world-class knowledge of Hungarian scientists and engineers, and they are setting up either their in-house R&D units or joint research groups with universities. Again, besides professional excellence, there is a considerable cost advantage in this field, too. Further, in the second half of the 1990s, R&D schemes were also applied to strengthen innovation capabilities of suppliers, and a new one was launched in 2006.

The successful re-structuring of the Hungarian automotive industry is not only due to some 'push' factors, i.e. the fierce competition among automotive companies and hence the pursuit of cost-cutting via re-location of their production, but it also thanks to 'pull' factors, i.e. the attractions of the Hungarian economic environment, broadly defined. Given the ever changing, and global nature of the automotive industry, no country can be complacent. On the contrary,

continuously renewed, concerted efforts and well-devised policy measures are needed to achieve further results.

### **Manufacture of medical instruments (NACE 33.1)**

The share of the medical instruments industry in the national GDP has reached to 0.1% by 2003, thanks to a healthy growth in its production value, albeit from a low absolute number (from 94 mio. EUR in 1998 to 194 mio. EUR in 2003).

The private R&D expenditures in NACE 33.1 amounted to 1.5 mio. EUR in 2004, up from 0.8 mio. EUR in 1998. The share of R&D expenditures of the medical instruments industry in the total BERD amounts to 0.5%, that is, 0.6% of the private R&D expenditures in the manufacturing industry.

The number of researchers has increased by four times since 1998. The total number of researchers reached 214 (head counts) in 2004, which represents around 2.4% of the total number of researchers in the private sector.

The R&D-intensity of the sector is not only higher than that of the whole electrical and optical instruments sector but it also produces higher growth. These tendencies are in line with the changes that can be observed in the industry at the EU-25 level.

The most important trends in the world's medical instruments industry play a determining role in the innovation activities of Hungarian companies. These trends include the increasing use of IT systems built into medical equipment, the revolution of digital imaging equipment and the expansion of the home-use appliances market. Besides R&D of the traditional equipment, Hungarian medical equipment manufacturers proved successful in the development and application of these product families.

Unfortunately, further data is not available for the analysis of the effects of R&D on the performance of the Hungarian medical instruments industry. Studies and sectoral analyses that systematically analyse the relationship between R&D and company performance are not available.

## **2.5. Latvia**

The current level of R&D in Latvia is comparatively low. In terms of the level of spending on R&D relative to the gross domestic product (0.4%) Latvian R&D intensity is one of the lowest in the EU. In fact, in the early 1990s, spending on R&D experienced a significant decrease from which it has not yet recovered. As a result, while GDP growth rates have been high, in recent years the highest in the EU, most economic activity still takes place in low value-added sectors.

This situation can be partly explained by rapid economic restructuring following the abandonment of the command economy. Prior to the reform, much of the applied R&D was concentrated in the research divisions of uncompetitive enterprises inherited from the USSR. Over the course of the reforms, many of these companies were closed down. Coupled with a drastic fall of government funding for science, this caused a dramatic decline in R&D performance.

Another reason for the currently insufficient private R&D effort is the lack of a coherent innovation policy throughout most of the 1990s. Initial policy documents either did not concentrate on innovation, or else lacked concrete measures to be taken and were not backed by pledges of funding. Only in 2001 the government adopted the National Innovation Concept. On the basis of the concept the National Innovation Programme for 2003-2006 was later approved. The most recent document concerned with innovation is the National Development Plan for 2007-2013. The main goal of the plan is to create a knowledge-based economy; correspondingly, R&D activities are heavily stressed.

## **Manufacture of chemicals and chemical products (NACE 24)**

The chemical industry is one of Latvia's traditional industries. Almost half of its turnover is generated by pharmaceutical companies. In turn, the pharmaceutical sub-sector is dominated by two large firms. Currently, the turnover of the sector is growing after a brief decline following the Russian financial crisis in 1998. Value added in chemicals and chemical products has grown to just over 50 mio. EUR in 2003 representing a share of 0.51% of GDP.

It is an industry where R&D is traditionally emphasized, particularly among the pharmaceutical companies, as innovation is necessary to remain competitive in this sector. Compared with other industries, companies in NACE 24 spend a much higher percentage of their turnover on innovation – with large pharmaceuticals producers contributing approximately 10% – and employ proportionally more workers in R&D roles than most other Latvian firms. Smaller companies, on the other hand, spend much less, mainly due to high costs of research in this field. The recent trend also shows that the share of R&D expenses in turnover is growing. Thus expenditures on R&D have grown from nearly 1.7 mio. EUR in 2001 to nearly 2.4 mio. EUR in 2003. This represents nearly 63% of manufacturing R&D and just over 18% of all BERD.

In addition, companies working in the chemicals sector have benefited from a relatively well-developed local scientific base. This especially applies to larger producers, who frequently cooperate with research institutes. As a result, the largest pharmaceutical companies are able to maintain innovative potential and register new patents regularly.

At the same time, lack of human resources is becoming an acute problem for enterprises in the industry, as the Latvian education system does not ensure a sufficient number of university graduates specialising in the relevant fields. Nevertheless, the total number of staff in R&D has grown from 156 in 2002 to 234 in 2004 and of these the researcher head count is up from 119 to 126. The latter number represents just over 69% of researchers in manufacturing and nearly 23% of all private researchers.

Additionally, the burden of administrative requirements, particularly those related to quality standards, is a significant obstacle for companies, as meeting these requirements demands investments which are diverted from R&D programmes.

## **Other business services (NACE 74)**

The NACE category 74, other businesses services, includes miscellaneous services such as advertising, legal, audit, consulting services, etc. The turnover and the number of companies in this industry were rapidly growing in the 1990s, as the sector was practically non-existent prior to the 1990s. By 2003 value added in the sector was nearly 248 mio. EUR representing a share of 2.5% of GDP (up from 522 mio. EUR in 2001 or a share of just over 2.2% of GDP).

R&D spending in the sector constitutes almost a half of the total private R&D spending. Although it is rather variable – thus in 2001 total R&D in this sector was 3 mio EUR, in 2002 it was nearly 6.7 mio. EUR and in 2003 just over 5.9 mio EUR. The latter represented nearly 46% of all BERD and was about 57% more than BERD in manufacturing. This, however, could have been caused by the nature of NACE group 74, which contains companies not included in other groups. Unfortunately, it is impossible to determine the pattern of R&D spending in different sub-groups of NACE 74, although these sub-groups are clearly very diverse.

Still, based on survey data it can be said that companies in the sector generally regard innovation as being important for boosting efficiency of operations, improving quality of services, or meeting regulatory requirements. At the same time, some companies express the view that available human resources are insufficient to ensure optimal R&D process. In 2002 1336 people were employed in R&D representing nearly 57% of all private R&D employees, Out of

the 1336 employees, 522 were researchers (46% of all private researchers). By 2004 these figures were respectively 219 (19%) and 93 (nearly 17%).

### **Manufacture of textiles (NACE 17)**

The textiles sector is another industry with a long tradition in Latvia. Currently, however, it is endangered by rising labour costs. As a result, companies find it increasingly difficult to compete with countries with cheap labour. Consequently, the sector has shrunk with value added in 2003 at just over 62 mio. EUR (0.63% of GDP) down from 108 mio. EUR (nearly 1.2% of GDP) in 2001.

Investment going to innovation is increasing, possibly reflecting an attempt to offset the negative effects of international competition. Nevertheless, the industry still spends little on innovation compared to other sectors. In addition, companies' ability to engage in R&D is constrained by a very limited domestic scientific base. In contrast to sectors such as chemicals, there are no specialised research centres working in fields relevant for the textile industry, and as a result, firms are rarely able to use external expertise in their R&D effort. Thus in 2003 only 0.219 mio. EUR was spent on R&D, which represents 5.8% of manufacturing R&D or nearly 1.7% of BERD.

Furthermore, human resources represent another potential bottleneck. While existing workers are relatively highly qualified, only a handful of university students choose to specialise in relevant fields. Thus, companies are likely to face a problem of increasingly ageing staff in future, which may become another obstacle for their R&D process, and may further endanger their competitiveness. In 2003 there were just 13 researchers in the sector representing just over 7% of researchers in manufacturing and 1.85% of all private researchers. The sector reported just one backup worker in R&D in 2003.

### **Manufacture of fabricated metal products (NACE 28)**

Manufacture of fabricated metal products is one of Latvia's fast-growing sectors, having nearly doubled its turnover between 1999 and 2003. Value added in 2003 was 53 mio. EUR or 0.53% of GDP. Research and development, however, does not play a major role, taking up less than 0.5% of the sector's turnover. Those R&D activities that do take place are mostly performed by large companies in the sector. Probably the cost and risk of innovation are being too large for smaller firms. In 2003 R&D expenditures were 0.47 mio. EUR or just over 12% of manufacturing R&D (3.6% of BERD).

As in many other industries, innovative activities in this sector are limited by a lack of engineering graduates, as the demand for them is much higher than the numbers that are available. In addition, many companies complain about recent graduates being insufficiently qualified. In 2004 only 4 people were reported as working in R&D in the sector, none of whom were actual researchers.

To ease the recruitment problem, many companies try to attract students at early stages of their university studies, offering jobs or internships. There is also substantial cooperation between enterprises and universities, in which the former offer scholarships to students or financial aid to the schools. Nevertheless, this collaboration has not been extended to more direct cooperation in the R&D process between firms and universities or research centres, particularly due to high costs, insufficient scientific base, and lack of information.

## **2.6. Lithuania**

The selected sectors represent traditional branches of the manufacturing industry in Lithuania and contribute significantly to the economic activity of the country. However, the analysis was restricted by the two factors. First, business R&D investments and therefore R&D employment are very low. Second, due to the limitations that are given for a small country such as

Lithuania, there is no reliable statistical evidence to support even this argument. Therefore the analysis is mainly based on evidence from case studies conducted.

Lithuania is dominated by the traditional industries, basically competing on costs, and facing the challenge of increase of productivity which still remains below 50% of EU average. R&D activities are performed by few companies in each of the selected branches, and its quality and orientation differs widely.

In the aftermath of the Russian crisis of 1998, the economy quickly recovered from the external shock. GDP grew over 6% in 2001-2002 annually and 9.7% in 2003, however this was the peak after which the real GDP growth fell to 6.7% in 2004, and 7.5% in 2005. Although growth is expected to remain high for the next few years, the vital need for new growth resources is obvious. Productivity growth, reduction of energy use in production and knowledge-based innovations are key challenges for the Lithuanian economy growth in the next future. Analysis of the country competitiveness shows that Lithuania is still competing on costs, and the next challenge is upgrading productivity in industry and transforming low value added activities into high productivity and high value added industries.

The bulk of Lithuanian R&D resources are concentrated in the public sector. Further concentration is encouraged with funding mechanisms, which drives 90% of public funding to public R&D institutions. Competitive funding for R&D remains very low.

Knowledge creation indicators such as public R&D expenditure, business R&D expenditure, and share of medium-high tech R&D remain far below the EU-25 level. Accumulated funds from all sources for R&D and higher education constituted 2.2% of GDP. According to official statistics, 381 mio. LT (1 EUR = 3.45 Litas) were allocated for R&D in 2003. 35.5% were used to finance fundamental research, 38% for applied research, and 26.5% for experimental development.

In 2002, R&D activities were performed by 67 enterprises, and 58 mio. LT were devoted for R&D activities in enterprise sector. The public sector was subsidising private R&D activities with 36 mio. LT in the same year.

Despite the increased numbers of PhD graduates, in the period 1998 – 2003 numbers of researchers decreased by 22%. The R&D sector therefore faces a aging problem in the near future. Today, in the age group of 25 - 34 there are 3 times less researchers than in EU, and 5 – 7 times less than in Finland and Sweden.

Restructuring of R&D sector and development of R&D based businesses is not only the economic target for Lithuania, but also a tool for reducing brain drain of highly skilled people, especially in the priority areas – biotechnologies, lasers, ICT, mechatronics and nanosciences. The R&D potential lies in the development of logistic applications, automatisations of manufacturing processes, environmental innovation, as well as in the cross cutting high technology fields, such as biotech, lasers, mechatronics, material and nano sciences, and ICT.

Besides some other RTDI-policy measures, the government introduced an indirect support of R&D by means of a new tax regulation which has been in force since 2005. This modification of the revenue act enables business entities to deduct expenses spent on R&D from their tax base. The impact on R&D activity and outcome remains to be evaluated.

### **Manufacture of food products and beverages (NACE15)**

The Lithuanian food industry is one of the largest industries in the country in terms of contribution to GDP, and the largest employer among all industrial sectors (40 thousand employees). It covers production of dairy, meat, cereal refining industries, production of sugar, beverages, etc.

The share of food products and beverages in the national GDP has always played an important role. Although, as a consequence of the decline of Eastern export markets and general

deindustrialisation of the country, it declined from 3.9% of GDP in 2000 to 3.5% of GDP (1832. mio. EUR) in 2005.

Dairy products, meat and cereal industries are identified as the most competitive sectors. In 2002 these comprised 17% of all industrial business entities. Although, the relative importance of the food industry decreased from 30% in 1999 to 24% in 2002, it remains the largest industrial sector with continually growing sales and exports. In terms of competitiveness and international exports, dairy industry is most successful, comprising 19% of total food sector employment (8,600 employees). In recent years, the sector has undergone a process of significant market consolidation. Only 19 out of 37 enterprises had licences for EU trade in 2002. 47% of total production was exported to USA, Netherlands, Russia, Latvia, and other countries.

The sector basically faces the challenge of international competition. Likewise the sector is challenged by ensuring high level food safety standards, applying new and safe manufacturing technologies, development of healthy and ecological products. Large enterprises run their own food safety research labs, but they are mainly responsible for quality control rather than research duties.

The private R&D expenditures in NACE 15 - amounted to 1.7 mio. EUR in 2003, R&D expenditures in this sector fell by 0.19% from 2000 to 2003, but increased by 50% in 2003, compared to 2002. The share of R&D expenditures of the food industry in the total BERD exceeds 7.2 %, which is more than 12.2 % of the private R&D expenditures in the manufacturing industry.

The number of researchers has been decreasing since 2000. The total number of researchers was 52 (FTE) in 2003, which represents more than 7.8% of the total number of researchers in the private sector in 2003 and about 11% of researchers in the manufacturing industry.

R&D intensity in the food industry is driven by internationalisation and the need to meet international quality and food safety standards. R&D also focuses on new product development and the application of new packaging technologies. Development of ecological food products is a new trend involving agriculture and food research.

R&D investment is focused on acquiring and adjusting new production technologies with the main aim of improving food quality and food safety. Development of new products in most of the cases is carried out by the internal staff in enterprises, or, in rare cases, in co-operation with research organisations. In the meat-industry, major technology developments were related to the acquisition of modern technologies via SAPARD support schemes. Product development remains limited to the internal company resources or is increasingly supply-side driven.

### **Manufacture of chemicals and chemical products (NACE 24)**

The share of *chemicals and chemical products* in the national GDP has always played an important role. It has kept its share of 1% of GDP in the period of 2000 to 2005. It produced 1% of GDP (581,922 mio. EUR) in 2005. The sector is highly diversified and not equally competitive. Mineral and organic fertilisers are producing most value added. Genomic engineering firms are competing on the global high-tech markets. The sector exported 75% of total production. Most of cost-competitiveness is based on the relative low costs for raw material, imported from Russian Federation. Home chemical and pharmaceutical industries are weakly developed.

Producers of fertiliser export 80% of total production, home chemicals (30%), pharmaceuticals (30%), synthetic fibres (80%), bio-technology products (90%). The export markets of fertilisers and biotechnologies are western, while those of pharmaceuticals and home chemistry eastern. The most important challenge faced by the chemical industry was the membership in the EU. To profit from the EU economically, higher environmental standards had to be met

which was achieved by large enterprises, but not by SME's.

As in many other countries, Lithuania's chemical industry is among the largest R&D investors in the country. The sectors' R&D investments comprised 29% of total BERD in 2003. The private R&D expenditures in NACE 24 - amounted to 6.78 mio. EUR in 2003, R&D expenditures in this sector increased with 10 times from 2000 to 2003. The share of R&D expenditures of the chemical industry in the total BERD exceeds 7.2 %, which is more than 12.2 % of the private R&D expenditures in the manufacturing industry.

The total number of researchers was 77 (FTE) in 2003, which represents more than 11.6 % of the total number of researchers in the private sector in 2003 and about 16.8 % of researchers in the manufacturing industry.

The biotechnology sector consists of four not highly interrelated specialised companies. In economic terms biotechnologies are of moderate importance today, since they only comprise 0.1% of the national GDP and employ only 300 people. The potential of the sector highly depends on public R&D infrastructure, research base and competencies, since the companies themselves are not capable to develop brand new applications and basically are running on the innovative solutions, which formed the base for their spin-off. However, new solutions and patents are needed in order to keep competitive in the future, and companies are not capable of developing significant novelties without strong public R&D infrastructure. This research infrastructure is well developed, and comprises several public research organisations: State Research Institute of Biotechnology (IBT), State Research Institute of Biochemistry, Institute of Chemistry and Institute of Botany. The Institute of Biotechnology was especially successful in developing spin offs - all 4 biotechnology companies came from this institute.

The biotechnology sector is the most R&D intensive sector, however it is represented by a few companies only, generally spin-offs of the Institute of Biotechnologies, and is concentrated in one city (Vilnius). It is highly dependent on the development of biotechnology science and its progress in Lithuania. However, the biotechnology industry today does not comprise an important share in the industrial structure, therefore investments are limited. The new wave of growth should be reached by the implementation of Industrial Biotechnology Development programme, approved by the Government in 2006.

### **Manufacture of machinery and equipment (NACE 29)<sup>13</sup>**

Manufacture of machinery and equipment is one of the most important branches of Lithuanian industry, with a long tradition and widely developed industrial branches. Historically, the higher-education system is largely oriented towards this industrial sector.

The share of manufacture of machinery and equipment in the national GDP was 0.6 % (250,747 mio. EUR) in 2005. Compared to 2000, it has increased with 0.1 % point. In the light of strong deindustrialisation, it is important to notice, that the sector has maintained its share of GDP.

There are over 700 enterprises in Lithuania, which can be assigned to the sector of machinery and equipment. It employs over 41 thousand people and creates 18% of GDP of total manufacturing. The sector's products represent 17% of total Lithuanian exports. Over 50% of employees are employed in large enterprises (over 250 employees), and sales of those enterprises make up for 60% of total sales of the sector.

The industry was one of the most affected by the process of deindustrialisation. Due to the orientation toward basic, non-specialised products, and low quality standards, production volumes in 1997 dropped by 84% compared to 1990.

The private R&D expenditures in NACE 29 amounted to 0.96 mio. EUR in 2003, R&D expenditures in this sector increased with 15% from 2000 to 2003. The share of R&D expenditures

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<sup>13</sup> Data are available for the aggregate NACE 27 to 29



of the machinery and equipment industry in the total BERD exceeds 4.1%, which is more than 6.9% of the private R&D expenditures in the manufacturing industry.

The number of researchers has been decreasing since 1998. The total number of researchers was 64 (FTE) in 2003, which represents more than 9.6% of the total number of researchers in the private sector in 2003 and about 14 % of researchers in the manufacturing industry.

Differently from other sectors, it is one of the few sectors, where not only public, but also private research organisations exist – “GTV” (mechatronics solutions), and a few other.

The sector is hardly finding its way in the modern competitive landscape. Its development is also not supported by public R&D and knowledge centre. Therefore, the government plans to establish an excellence centre for mechatronics in Kaunas with the support of EU structural funds. It aims to connect the needs of enterprises and researchers in development of measurement and medical equipment. The initiative was taken because of the high variety of industry and non-existence of a single strong enterprise that would be able to lead joint R&D efforts of the sector and perform significant modernisation of the sector. In general, local R&D activities are associated with the adoption of imported technologies to local needs and to resolving technology compatibility problems.

### **Manufacture of medical, precision and optical instruments, watches and clocks (NACE 33)**

The share of manufacture of electrical and optical equipment (NACE 31 – 33) in the national GDP is 1.3%. The manufacture of medical, precision and optical instruments, watches and clocks comprised 80.9 mio. EUR in 2005. The sector consists of 40 enterprises. All of them are SME's. Only nine firms are high-tech and R&D oriented, primarily in laser technology. Over 95% of Lithuanian laser production is exported to the EU, Switzerland, Japan, USA. In total, products are exported to 100 countries. The sector employs 250 persons, 30 of them are scientists. The development of the laser technology industry in Lithuania is related to the foundation of an experimental manufacturing company in 1983 by the Science Institute of Physics. Most of the Lithuanian light technology enterprises span off the Institute of Physics. Vilnius university also has generated a spin-off called, „Light conversion“. There are also foreign capital initiated companies, such as "GEOLA".

Major laser companies could build a potential cluster, as all related companies are situated in Vilnius and most of them in the Technology park „ Sunrise valley“. Still, joint R&D activities remain of an ad hoc type. The establishment of the excellence centre should lead to further R&D activities and investments.

The private R&D expenditures in NACE 33 amounted to 0.78 mio. EUR in 2003, R&D expenditures in this sector increased 4 times from 2001 to 2003. The share of R&D expenditures of the medical and optical equipment industry in the total BERD exceeds 3.4%, which is more than 5.7 % of the private R&D expenditures in the manufacturing industry.

The number of researchers in the sector is one of the highest compared to other sector. The total number of researchers in the whole sector (NACE 31-33) was 135 (full time equivalent - FTE) in 2003, and the sub-sector of manufacture of medical, precision and optical instruments employed 70 researchers (FTE) The sector represents more than 7.1% of the total number of researchers in the private sector in 2003 and about 15.2% of researchers in the manufacturing industry.

A key factor that could impact future R&D activities is the development of the mechatronics cluster, and implementation of the national High-technology Development Programme. The development of mechatronic products and lasers are two of Lithuania's scientific research priorities and at the same time two of the high-technology priority areas.

R&D co-operation in new technology and product development occurs within the Department of Quant Electronics of Vilnius University, and Institute of Physics. R&D funding originates from various initiatives, such as Eureka, COST, FP6, but also programmes supported by the NATO.

### **2.7. Malta**

The dependency of the Maltese economy on two key sectors, tourism (a major contributor to output growth, employment creation and foreign exchange generation), and electronics in manufacturing (semi-conductor) industry and their vulnerability related to the global business cycle and shock events highlight the challenge of sustaining the present economic development and quality of life.

The Maltese economy became more services-oriented between 2001 and 2005 and less dependent on industry and agriculture. Total manufacturing value added at factor cost fell however value added per capita registered a marginal increase reflecting lower employment levels. The growth rate in value added per capita declined whilst real value added per capita (productivity) registered a subdued rise.

The transition to services and to sectors with a closer fit to the current “educational and skills profile of the country's knowledge-driven labour pool”, including new high value-added sectors

such as financial services (12% of GDP), Freeport related activity, ICT, aviation maintenance and repair, business process outsourcing and the pharmaceutical industry (25 companies), indicates that the economy is “in a state of flux, in search of that economic push that will see it go steadily forward”.

There is no doubt that Malta’s current investment level in R&D, public and private, is minimal, both in absolute amounts and as a percentage of GDP, that they are constraining national efforts to attract and retain high-tech FDI and to move up the technological ladder.

Until as recently as 2002, statistics on national spending on R&D were not available, resulting in a lack of awareness among policy makers of the extent to which the country was lagging behind in this critical area. Whilst progress has been achieved, much is yet to be achieved (see table 1). Although figures for 2005 have not yet been released, it is estimated that the national R&D investment for 2005 is in the region of 0.3% for public investment and a further 0.3% for private investment, that makes a total of 0.6% of GDP spent on R&D based on preliminary indications of a substantial increase in the business investment.

R&D activity in the business sector is largely concentrated in 30-40 firms and is clustered around a number of specific sectors, mainly related to high value added manufacturing in ICT, manufacture of machinery, manufacture of chemicals and medical instruments, financial intermediation, food and beverage. The incentives offered are typically to finance capital investment that may well explain why procurement of new equipment is by far the more popular way of acquiring new technologies.

### **National Framework Conditions**

The low level of R&D activity which features in Maltese industry is a consequence of a dual economy; the number of indigenous SMEs with a low level of in-house research capacity. Poor R&D activity in the public sector is concentrated around a number of research institutes and innovation centres linked to the Ministries.

Malta Enterprise is currently engaged in a number of R&D policy development actions and measures including Innovation Policy Development, Technology Transfer, Networking for Innovation and promoting innovation management techniques.

Malta Enterprise is currently operating 22 schemes to support FDIs and local enterprise, with 12 schemes extending to cover R&D and innovation, but only one scheme, the Research and Development Tax Credit, introduced last year, supports R&D activity exclusively. Innovative start-ups are supported through the Business Incubation Centre where they benefit from managerial assistance as well as small grants and access to schemes to facilitate investment in capital assets.

The experiences of the chosen case studies indicate that the presence of a director influencing employee with international experience and a post-graduate degree in the subject is the soundest way of ensuring the required migration into a valid R&D function within the enterprise. However, the family influence on this migration is deemed as typically negative in any of the indigenous companies. Incentives are required to encourage companies to use such PhDs in their R&D crossover whilst at the same time support the owners in dealing with the resistance emanating from their long serving conservative staff.

### **Publishing and Printing (NACE 22)**

The publishing and printing sector’s share in total value added fell to 6.3% of the total manufacturing in 2004 from 6.9% in 2003 and 8.1% in 2002.

The private R&D expenditures through the acquisition of new production equipment in NACE 22 in 2004 was 12.7 mio EUR. There were no previous annual figures recorded and thus a comparison is not possible. This amounts to 0.3% of the 2004 GDP.

Research staff totalled 2 out of a total estimated employment of 2019 within 217 companies. There are no previous records available for comparison, too.

The sector's personnel costs per capita registered an annual average growth rate of 9.7% between 2001 and 2004, exceeding the average for the total manufacturing industry by 14.2% in 2004. Gross operating surplus rose by 25.9% in 2002, and fell subsequently in the following two years to nearly half the level recorded in 2001. Following a 22.3% rise in the sector's value added at factor cost per capita in 2002, a decline of 14.2% was recorded in 2003, followed by a decline of nearly the same magnitude in the following year.

The total number of employees in the manufacture of pulp and paper products (including publishing and printing) was 1,875 representing a decrease of 46 over the previous year. Consequently, at the end of September 2005, the share of the manufacture of pulp and paper products (including publishing and printing) sector in manufacturing stood at 7.7%, unchanged from the rate recorded during September 2004. Most of the companies within this sector employ less than 9 (84% of companies) and only two employ more than 250.

The only areas of R&D recorded in this sector is through the direct acquisition of machinery and equipment that included advanced machinery, computer hardware/software specifically purchased to implement new or significantly improved products (goods/services) and/or processes. Some investment on R&D training was also indicated. In this sector there were no R&D expenditures within the enterprises (intramural), either as current, capital or labour expenditures for R&D performance. There also was no commissioned R&D performed by other units (extramural R&D, including other enterprises within the group) or other public or private research organizations on R&D (extramural).

The only significant investment on acquisition of machinery and equipment is by an FDI printing enterprise that may skew the statistics. Furthermore there is an abnormally high number of companies listed under NACE 22.22 (printing not elsewhere classified) that could be interpreted as poor classification. There were 2 companies in NACE 22.22 that received government financial aid to invest in capital equipment that was registered as being commensurate to research funding.

Factors important for the industry include increase in quality, reduction of waste, increase in productivity, better capital utilisation, and training.

The data indicates that smaller sized companies are not investing in R&D. Data also implies that indigenous companies are smaller companies and invest less in R&D. The larger ones seem more prone to investment particularly with the aid of the Malta Enterprise financial assistance. However the R&D investment seems solely limited to the acquisition of the latest machinery as the way for technology upgrade.

### **Food, beverages and tobacco (NACE 15)**

The food, beverages and tobacco products sector's share in total value added reached 16.8% of the total manufacturing in 2004 from 16.6% in 2003 and 15.3% in 2002.

The private R&D expenditures have been mainly dominated by the acquisition of new production equipment in NACE 15 in 2004 and was at 3 mio. EUR. There were no previous annual figures recorded and comparison is not possible. This amounts to 0.07% of the 2004 GDP.

Research staff totalled 35 out of a total estimated employment of 4,704 within 646 companies. There are no previous records available for comparison.

R&D in the food sector also seems slightly more varied than just technological development through equipment procurement alone, even if procurement still remains the most significant factor. Data implies that the food sector has a healthy local market particularly amplified during the tourist seasons. R&D efforts reported indicate a wider take-up even with the smaller and indigenous enterprises.

The contribution of the food, beverages and tobacco sector to total value added remained the second largest in the industry. The sector's share in total value added fell marginally to 15.3% in 2002 from 15.6% a year earlier. However this decline was reversed in the following year when the share rose to 16.6% in 2003. In 2004, the food, beverages and tobacco products sector's contribution in total value added rose by a further 0.2 percentage points, to 16.8%.

R&D is predominantly performed in two sub-sectors: NACE 15.89 (food not elsewhere classified) and 15.90 (beverages). However bread (NACE 15.81), fruit and vegetables n.e.c. (NACE 15.33) and wines (15.93) also seem to invest in R&D staff even though financial investment was not recorded.

The greatest source of technology acquisition is through the acquisition of machinery and equipment. However there is also some investment in training/marketing/design as well as extramural research.

### **Manufacturing of machinery and equipment (NACE 29)**

The manufacturing of machinery and equipment sector's share in total value added reached 1.6% of the total manufacturing in 2004 from 1.5% in 2003 and 1.2% in 2002.

The private R&D expenditures mainly through intramural R&D in NACE 29 in 2004 was at 0.38 mio EUR, which amounts to 0.01% of the 2004 GDP. There were no previous annual figures recorded. .

Research staff totalled 14 out of a total estimated employment of 571 within 57 companies. There are no previous records available for comparison.

During 2002 to 2005, total exports declined by 198 mio. EUR (86.1 mio. Lm) to 1,369 mio. EUR (595.3 mio. Lm). This represents a decline of 12.6%. The machinery and transport equipment sector contributed to 9.9 percentage points of the decline in total exports. Another 3.1 percentage points was the result of the decline in fuel exports.

If one were to exclude exports of fuel and machinery and transport equipment sectors, it is interesting to note that exports in the first nine months of 2003, 2004 and 2005 remained stable at around 494 mio EUR (215 mio Lm). This occurred despite the trend decline in exports of clothing, traditionally the second major exporting sector. This indicates that exports in other sectors compensated for the decline in exports of clothing. During the period under review, a significant increase of 12 mio EUR (5.4 mio Lm) in exports of semi-manufactures was also recorded.

Notably different from the food and the printing sectors is that most of the R&D carried out in this sector is attributed to intramural activities. The sector is after all focused on the building of machinery so it follows that machinery and equipment procurement is not cited as being their source of R&D. The largest number of researchers as well as the largest investment in R&D was noted as within the sub-sector of non-domestic cooling and ventilation equipment.

Employment showed a decrease although productivity is shown to be increasing through increasing per capita sales, wages and exports.

### **Financial intermediation (NACE 67.2, 66.1)**

There are no figures available to compare this financial services sector with that of the manufacturing.

The private R&D expenditures comprise mainly the acquisition of new equipment in NACE 66.1 and 67.2 in 2004 was at 1.1 mio EUR. There were no previous annual figures recorded and thus comparison are not possible again. This amounts to 0.03% of the 2004 GDP.

No research staffs were noted out of a total estimated employment of 5530 within 221 companies.

R&D&I in this section was attributed to the acquisition of machinery and equipment with the most investment being carried out in central banking. This indicates that the data supplied included public investment.

The experiences of the chosen case studies indicate that the presence of a director influencing employee with international experience and a post-graduate degree is the soundest way of ensuring the required migration into a valid R&D function within the enterprise. However, the family influence on this migration is deemed as typically negative in any of the indigenous companies. Incentives are required to encourage companies to use the knowledge of PhDs in their R&D crossover whilst at the same time support the owners in dealing with the resistance emanating from their long serving conservative staff. This seems also particularly applicable to the financial services. Although the figures show that the industry is rapidly growing, some data indicates that it really is the longer established financial related companies that are growing. And these have the same conservative outlooks of the long-serving, now senior, staff who shun any progress into new technologies.

### **2.8. Poland**

The process of privatisation of the Polish economy has been conducted since 1988. It was influenced by 3 major streams: i) establishing of more than 2 millions of private active enterprises (among which the largest group consist of micro firms in services), ii) privatisation of former state owned enterprises by different formal procedures of privatisation such as sale to foreign investor, to domestic investor, IPO on Stock Exchange, sale to employees, mass privatisation, and iii) debt restructuring creditor companies as well as FDI in green field projects.

Main sources of expenditure for innovation activity in Poland in the private sector were based on own funds and bank credits. These two sources constitute together 95.3% of financial sources in this sector. Contribution of bank financing (16.5%) is almost two times higher than in public sector (8.5%) and differs according to ownership form. The foreign funds however contribute in smaller scale in financing of private sector (1% against 1% in public sector).

Almost all firms with R&D expenditures in machine industry in Poland are characterized by growth of sales. Foreign investor owned firms have better relation of R&D investments to sales. Increasing the R&D intensity to the level of the corporation imply spill-over effects on the regional level as well as country level. National firm R&D investments could give competitive position on the global market (e.g. coal mining machines).

The labour costs in Poland are still few times lower than in USA and Western Europe and at the same time there is plenty of skilled and well-educated labour force. These conditions may have attracted the largest foreign investors in Polish aviation sector like General Electric, United Technologies Holding S.A., EADS CASA, Pratt & Whitney Canada, Goodrich, Snecma and Avio. Those companies are willing to invest in R&D.

The automotive sector is interested in developing its own R&D entities because there is a huge demand on R&D in Poland. The first ones exist established by Delphi and TRW and the

others are to be established soon. The increase of employment in R&D activity of the sector was about 50% between 2003 and 2004. That proves that it is not possible to develop production facilities and launch new products without investing in R&D activities.

Private firms developed by the innovative entrepreneurs in NMSs are able to construct corporate management structure, understandable motivational system, invest in R&D and thanks that became competitive on the European and global market. This opportunity is the chance for diminishing the R&D concentration as well as to introduce new dynamics in the ERA.

### **Manufacturing of Machinery and Equipment n.e.c. (NACE 29)**

In 2005, the share of NACE 29 in the value of sold production of the whole manufacturing industry was about 4.4% and amounted to 26,038 mio. PLN (6,816 mio. EUR), which was 111.5% of the value in 2004.

The intramural R&D expenditures amounted to 180 mio. PLN (47.3 mio. EUR), which was more than 10% of the total intramural R&D expenditures in the whole manufacturing industry and 118.2% of the expenditures from 2004. The intramural R&D expenditure from own sources (equivalent of BERD) amounted to 153 mio. PLN (25.75 mio. EUR) which was more than 12% share in the whole industry expenditures (1,255 mio. PLN = 328.7 mio. EUR).

The total number of employees in R&D activities in enterprise sector in NACE 29 was 2117 persons, which represent more than 12% of the total number of employees in R&D activities in the whole manufacturing industry (16,846 persons) and about 83% of the number in 2004.

The expenditures for R&D in manufacturing of machinery and equipment are less stable than in other industries. They are very demand oriented. Structural changes of the industry influence the scale of R&D expenditures. The sector spent 77 mio. EUR in 1999, the year with highest R&D expenditure so far. After that period R&D investments decreased every year to the level of 21.5 mio. EUR in 2002. In the last years relatively fast growth could be observed. The level of R&D expenditures in 2004 is almost 40 mio. EUR.

The Polish industry of manufacturing of machinery and equipment is the 6<sup>th</sup> largest sector in terms of employees among EU-25 and the largest sector among the NMSs. In 2003 it employed more than 192 thousands persons. Altogether, there were 13,840 enterprises in 2004 of which 243 firms are still state owned. The sector mainly produces machinery for the power and coal mining industry. The largest enterprise in the sector is Alstom Power, which is the main R&D performer. Alstom's main factory is located in a region with high unemployment and without specialized scientific centers. Mobile R&D teams develop strong links with specialized technical universities in Lower Silesia, a region which long tradition in R&D.

Poland is one of the leading producers of machines for coal mining in the world. This sub-sector is characterized by high R&D intensity as patenting activity and firms are traditionally cooperating with technical universities.

There is no evidence for a direct impact between R&D intensity and sectoral growth. However, almost all firms with R&D expenditures are characterized by growth of sales. Foreign owned firms have better relation of R&D investments to sales. Firms specialized in coal mining machine are examples of winner companies thanks to the boom on the global markets. Though, the high growth of sales not always means relative growth of R&D investments in this sector. However, the level of investments is stable.

### **Manufacture of Pharmaceuticals, Medicinal Chemicals and Botanical Products (NACE 24.4)**

In 2005, the share of NACE 24.4 in the value of sold production of the whole manufacturing industry was above 1% and amounted to 6 377.86 mio. PLN (1 669.6 mio. EUR), which was 105.5% of the value in 2004. The intramural R&D expenditures amounted to 149 mio. PLN

(39.1 mio. EUR), which was more than 8% of the total intramural R&D expenditures in the whole manufacturing industry and 108% of the expenditures from 2004. The intramural R&D expenditure from own sources (equivalent of BERD) amounted to 148 mio. PLN (38.8 mio. EUR) which was almost 12% share in the whole industry expenditures (1,255 mio. PLN = 328.7 mio. EUR).

The total number of employees in R&D activities in enterprise sector in NACE 29 was 1027 persons, which represent more than 6% of the total number of employees in R&D activities in the whole manufacturing industry (16,846 persons) and only about 85% of the number in 2004.

The Pharmaceutical sector in Poland is characterised by very high outlay on R&D activities and the great majority (92.8%) of this outlay comes from enterprises' own sources. Additionally the expenditure on R&D in this sector systematically grows for the last 6 years and it can be seen that those expenses are mainly (in 93%) used for acquisition of new machinery and appliances. This indicates that there is great tendency on modernising the existing infrastructure in pharmaceutical companies.

The noticeable rise of R&D investments level in NACE 24.4 does not follow general trend in Polish R&D activity. Between 1999 and 2004 R&D investments fell by 20% in the whole manufacture sector, whereas in the same period there was a noticeable rise of 150% in NACE 24.4.

One of the biggest current problems of the pharmaceutical sector in Poland is its low level of privatisation and rather slow progress in selling the biggest state owned pharmaceutical companies to private owners. All the preparations, before the process of privatisation of the biggest companies started, took about 4 years, even though there was high interest of local and foreign investors.

Along with the accession of Poland to EU there occurred the problem of adaptation of European law and fulfilling its restrictions and standards. As the majority of local producers were concentrated on production of generic drugs there were some possible barriers, for example occurring from extension of exclusive data period that was intended to protect the rights of the drug inventor for several more years. Even more problems for local producers was implied by the regulations imposing the obligation of presenting very exact and detailed documentation for the production methods and quality of substrates used in every part of produced drugs in accordance to EU standards. An effect of the EU law restrictions is that the majority of Polish pharmaceuticals are exported to Eastern Europe, Middle East and other countries with milder quality and documentation restrictions. Still over 60% of drugs sold in Poland is imported.

One of the NACE 24.4 characteristics is the rapid growth of foreign investment beginning from the year 1998 when the privatisation of the sector started. Between 1999 and 2004 the number of R&D units in pharmaceutical sector has decreased on 8% compared to 14% in the whole industry, and the reduction of employees between 1999 and 2002 was only 3.2%, compared to over 25% in the whole industry. The percentage of R&D employees in NACE 24.4 amounted 7.8%. While in the whole manufacturing sector the number of R&D employees dropped radically about 36%, in NACE 24.4 there was 56% rise in researchers employed.

### **Manufacture of Other Transport Equipment (Aircrafts) (NACE 35.3)**

In 2005, the share of NACE 35.3 in the value of sold production of the whole manufacturing industry was only 0.14% and amounted to 834 mio. PLN (218.5 mio. EUR), which was 107% of the value in 2004.

The intramural R&D expenditures amounted to 60 mio. PLN (15.9 mio. EUR), which was more than 3% of the total intramural R&D expenditures in the whole manufacturing industry and about 94% of the expenditures from 2004. The intramural R&D expenditure from own

sources (equivalent of BERD) amounted to 24.7 mio. PLN (6.5 mio. EUR) which was almost 2% share in the whole industry expenditures (1,255 mio. PLN = 328.7 mio. EUR).

The total number of employees in R&D activities in enterprise sector in NACE 35.3 was 922 persons, which represent more than 5% of the total number of employees in R&D activities in the whole manufacturing industry (16,846 persons) and only about 88% of the number in 2004.

Poland has a long history in the area of aeronautics. The tradition of the Polish aircraft starts in 1910 with foundation of the "Aviata" aircraft factory in Warsaw in 1910. Before the First World War another four aircraft factories had been founded in Poland: in Warsaw, Lublin, Bi-ala Podlaska and Poznan, and one state-owned in Warsaw. After the Second World War and until 1989 Polish aircraft production was meant mainly for defence purposes and as such had many advantages like tax incentives and priority in material acquisition. After the transition this sector had many problems with accommodating to competitive conditions. It has suffered severely from the collapse of its traditional markets, because it was locked into outdated technologies and the beginning of the privatisation process was quite slow. But thanks to benefits from production of other civil equipment, such as agricultural aircraft and gliders, most of the companies managed to find foreign investors, mainly from the US. There is hope that the basis of an innovative aviation cluster is emerging.

R&D expenditure is strongly influenced by the public support. R&D investment in the aviation sector from the public sector is higher than private and foreign investment. Financing from public sources is 54% and 25% from domestic enterprises. Statistics between 1999 and 2004 show that the number of R&D units in NACE 35.3 has decreased only by 1 and the number of employees in R&D activities has slowly decreased and then rose to almost the same level. But it is worth noticing that in this figures the number of researchers increased while the number of technicians and other R&D units' employees decreased accordingly.

The aviation industry is being perceived as a thematic priority of innovative policy in Poland and in the whole Europe. The Polish market is the biggest in Central Europe and places itself among the biggest in the whole of Europe. In addition to the fact, that the aircraft sector is one of the prioritised branches of the industry in Europe it gives Polish companies great opportunity for development through cooperation with the world's largest manufacturers. The Aircraft Transport in Poland is carried out both by public entities and private companies. There are now about 55 aircraft related firms in Poland covering both the civil and military markets and employing some 16,000 people.

The boom in aviation companies, especially in southern Poland occurred when Pratt & Whitney became a strategic investor in WSK Rzeszow. Most of the production is exported, mainly to United States, Germany, Italy, Greece, Canada, Spain, Republic of South Korea and Vietnam. The labour costs in Poland and the availability of skilled and well-educated labour force attracted the largest foreign investors like General Electric, United Technologies Holding S.A., EADS CASA, Pratt & Whitney Canada, Goodrich, Snecma and Avio. Those companies are willing to invest in R&D.

### **Manufacture of Transport Equipment (Motor Vehicles, Trailers and Semi-trailers) (NACE 34)**

In 2005, the share of NACE 34 in the value of sold production of the whole manufacturing industry was above 10% and amounted to 60,634 mio. PLN (15,8723 mio. EUR), which was 106.7% of the value in 2004.

The intramural R&D expenditures amounted to 193 mio. PLN (50.5 mio. EUR), which was more than 11% of the total intramural R&D expenditures in the whole manufacturing industry and above 147% of the expenditures from 2004. The intramural R&D expenditure from own sources (equivalent of BERD) amounted to 178.5 mio. PLN (46.7 mio. EUR) which was more than 14% share in the whole industry expenditures (1,255 mio. PLN = 328.7 mio. EUR).

The total number of employees in R&D activities in enterprise sector in NACE 34 was 1,249 persons, which represent more than 57 of the total number of employees in R&D activities in the whole manufacturing industry (16,846 persons) and about 107% of the number in 2004.

The level of R&D expenditures as a percentage of total sales has reached 0.2% in 2003. Due to the dynamic development of the sector the share remained stable, based on a 55.4% increase of expenditures on R&D in 2004. Most foreign car manufacturers, or Tier 2 and 3 suppliers producing in Poland carry out their R&D activities outside of Poland. Delphi Automotive Systems and TRW are the first foreign investors who invested in R&D in Poland by creating R&D Centers in Krakow and Częstochowa. The number of R&D employees almost doubled from 2003 to 2004. This proves that there is a dynamic process taking place in R&D activity in the sector.

About 80% of production of the industry is exported. Poland became an important producer of diesel engines, which are assembled to such passenger cars like Opel, Volkswagen, Skoda, Seat, Audi, Fiat, Honda, Isuzu and Toyota. Receivers for produced spare parts or accessories are such well known companies like Daimler- Chrysler, BMW, Jaguar or Ferrari. Volkswagen and Fiat have started in Poland production of their brand new models (Caddy and Panda). Volvo and MAN have decided to increase their investments in Poland. Thanks to them, Poland is going to become the largest bus and coach producer in Europe.

Manufacturers are mostly private companies with foreign ownership; the state holds a minority share in only one firm. FDI in the sector is significantly higher than in the whole industry. About 20% of FDI in industry are accumulated in the transport equipment sector.

There is no clear evidence of the impact of R&D on transport equipment sector at the moment. Rather it can be proved that very poor R&D activities forces manufacturers to buy technology abroad. However, due to the dynamic development of the automotive market opportunities are used by many Polish producers by which demand for research activities in technical universities as well as specialized institutes may be rising. Spill-over effects of the development of automotive production and market can be observed in the whole economy based on FDI and private Polish innovative firms including tyre-manufacturing (Bridgestone, Michelin) and furniture producers (Inter Groclin with a market share of 5% of the European).

## **2.9. Slovakia**

High economic growth tends to be associated with R&D expenditure. Slovakia provides an interesting exception from this correlation. The rapid economic growth and rise in per capita GDP happened alongside deep fall in R&D expenditure, employment and infrastructure. Slovak experience, however, does not contradict to the assumption on a positive links between R&D expenditure and economic performance, if the effects of R&D spill-overs and technology diffusion are taken into account. Slovakia accounted for the highest rates of the purchase of technology equipment in the EU-25 area. Most of the technology diffusion was related to branches of the MNCs (Samsung, Volkswagen, Siemens, etc.), which accounted for high rates of R&D spending and top-notch technologies. Slovak branches of MNCs contribute to parent companies' turnovers and R&D spending and, in turn, profit from technology diffusion. In the year 2000, the Slovak economy accounted for significant increases in labour productivity. Data on productivity in domestic and foreign sectors indicate that MNCs were by far more productive than domestic firms. Hence, the relationship between R&D and innovation spending on one hand and productivity on the other hand is valid also for Slovakia.

### **National Framework Conditions**

Data by the 2005 European Innovation Scoreboard indicate that, with some notable exceptions, Slovakia ranked to the poorest innovation performers in the EU-25 area. Low spending on R&D was the major weakness of the National Innovation System in Slovakia. There has been a negative trend in R&D spending since 1989, when support to R&D peaked with 3.88

percent and subsequently decreased to 0.5 % of GDP in 2005. Slovakia accounted for very high innovation expenditure by companies (160% of the EU-25 average) and ICT expenditure (95% of the EU-25 average), which was related to purchase of high-tech equipment by branches of MNCs. FDIs were the reason for high levels of employment in mid/high-tech manufacturing (121% of the EU-25 average) and new to market product sales (239% of the EU-25 average). Slovakia failed to address some most serious problems in innovation performance, namely shares of business and public expenditure on R&D in GDP (38% and 25% respectively of the EU-25 average), University R&D financed by business sector (5% of the EU-25 average) and early stage venture capital (6% of the EU-25 average). The poor financial base of R&D system was reflected in a very low commercial output. Rates of patenting activity were only 3% of those in the EU-25 area.

By 2006, the Slovak National Innovation System consisted of a number of government, private and non-profit organisations. Most of these organisations (including private ones) were controlled and/or supported by the government and its agencies and initiatives. Major responsibilities within the National Innovation System were assigned to the Ministry of Education and Ministry of Economy. The Ministry of Education concentrated its role on the support of basic and applied research. Applied research also was supported via the public procurement and carried out via (private) industry research institutes. The Ministry of Economy managed a network of innovation support agencies which concentrated on implementation of various innovation policy measures, many of which were heavily dependent on EU funds.

Most innovation policies in Slovakia overlapped with S&T policies, which were designed and implemented by the Ministry of Education. The Ministry, however, lacked financial and human resources for managing industry research, and was not able to elaborate and implement policies aimed at commercialisation of R&D. Weak support for applied research was reflected in extremely low commercial output of the Slovak R&D sector. The Ministry of Economy and the National Agency for the Development of Small and Medium Enterprises (NADSME) designed and implemented a number of particular industry-oriented innovation policy measures, but were not able to formulate a coherent innovation policy framework. In general there is only a modest support to innovation activities compared to very generous assistance to major foreign low- and medium-tech investors (car producers in particular). The release of the *Strategy of Competitiveness Development in Slovakia up to 2010* (the Lisbon Strategy for Slovakia) and preparation of the new *Law on Organisation of State Support to Research and Development* (the Law No 172/2005) were major issues in debates on R&D and innovation policy in Slovakia in the period from 2004 to 2005. The Competitiveness Strategy is completed by four Action Plans, of which the Action Plan for R&D and Innovation accounts for the largest amount of financial means allocated. It indicates that government is serious about its plan to change Slovakia from a low-cost, low-value added economy to a knowledge-based one.

#### **Manufacture of motor vehicles and transport equipment (NACE 34)**

The share of manufacture of motor vehicles and transport equipment industry in the national GDP has increased from 1.9% in 2000 to 2.0% (655.5 mio. EUR) in 2004. Low numbers of reporting organisation disabled publishing data on R&D in this industry. The CIS 3 data (covering period 2001-2003) are used as a proxy. Thus, the share of manufacture of motor vehicles and transport equipment industry in the total BERD in manufacturing can be estimated to some 10 % (about 5.14 mio. EUR). There are no data on researcher numbers published for this industry, too. The car industry has already become a top sector in Slovak economy. It will even increase in importance when Hyundai-Kia and Peugeot-Citroen will start their production in 2006. By 2005 the industry was dominated by Volkswagen and its suppliers. All these were branches of foreign multinationals. None of these assembly and/or production plants reported R&D activities in Slovakia. The overall R&D capacities in this industry, however, are quite low by international standards. The car and car components productions in Slovakia seemed to profit much more from technology diffusion from existing R&D units abroad rather than from domestic R&D activities.

### **Manufacture of base metals and fabricated metal product (NACE 27-28)**

This industry is one of the oldest and most important Slovak industries. The industry enjoyed huge increases in labour productivity. In period 2000-2004 employee numbers dropped, but sales increased by one half, while amount of total value added and value added per employee doubled.

The share of the manufacture of base metals and fabricated metal products industry in the national GDP has increased from 3.4% in 2000 to 4.1 % (1,342.4 mio. EUR) in 2004. The private R&D expenditures in NACE 28 only (no data on NACE 27 due to individual data protection) amounted to 0.78 mio. EUR in 2004. There also were no data on BERD development in period 2000-2004. Individual data protection in some industries disabled computing BERD in total manufacturing industry. If the CIS 3 data (covering period 2001-2003) are used as a proxy, the share of the manufacture of base metals and fabricated metal products industry in the total BERD in manufacturing can be estimated to some 4.3 % (2.17 mio. EUR). However, there are no data on development of researcher numbers in this industry, due to individual data protection.

### **Manufacture of rubber and plastic products (NACE 25)**

The share of rubber and plastic products industry in the national GDP has increased from 0.8% in 2000 to 1.0 % (326.0 mio. EUR) in 2004. The private R&D expenditures in NACE 24 amounted to 7.9 mio. EUR in 2004. The private R&D expenditures in this sector increased from 4.11 to 7.57 mio EUR in period 2000-2004. The share of R&D expenditures of the rubber and plastic products industry in the total BERD exceeded 11.4% in 2004. Individual data protection in some industries disabled computing BERD in total manufacturing industry. If the CIS 3 data (covering period 2001-2003) are used as a proxy, share of the rubber and plastic products in industry in the total BERD in manufacturing can be estimated to some 15 %. The number of researchers has been decreasing since 2000. The total number of researchers (FTE) dropped from 171 in 2000 to 140 in 2004, which represents more than 4.0% of the total number of researchers in the private sector in NACE 25 in 2004 (there are no data on researcher numbers in total manufacturing sector). The industry R&D actually consists of the firms Matador and VÚSAPL. Matador has strong research department and, on Slovak standards, performs good quality company research. The R&D activities enable Matador to flexibly react on changing demand on the market for tyres.

### **Manufacture of chemicals, chemical products and man-made fibres (NACE 24)**

The share of manufacture of chemicals, chemical products and man-made fibres industry in the national GDP has fallen from 1.3% in 2000 to 0.6 % (202.8 mio. EUR) in 2004. The private R&D expenditures in NACE 24 amounted to 7.4 mio. EUR in 2004. The private R&D expenditures in this sector fell by 1.25 times from 9.27 to 7.20 mio. EUR in period 2000-2004. The share of R&D expenditures of the manufacture of chemicals, chemical products and man-made fibres industry in the total BERD exceeded 11.2% in 2004. Individual data protection in some industries disabled computing BERD in total manufacturing industry. If the CIS 3 data (covering period 2001-2003) are used as a proxy, share of the manufacture of chemicals, chemical products and man-made fibres industry in the total BERD in manufacturing can be estimated to some 15 %. The number of researchers has been decreasing since 2000. The total number of researchers (FTE) dropped from 332 in 2000 to 127 in 2004, which represents more than 3.7% of the total number of researchers in the private sector in NACE 24 in 2004 (there are no data on researcher numbers in total manufacturing sector). Despite recent decreases in BERD and researcher numbers, this sector accounts for probably one of the best research infrastructure among Slovak manufacturing industries. Thus, the industry experienced a range of difficulties, which heavily impacted its competitiveness (company restructuring, rising costs of inputs, implementation costs of the REACH legislative, etc.). The cost-cutting involved reduction of the R&D base. In 2004 and 2005 some key business players were bought by foreign (mostly Czech) investors and became parts of international business groups. The process of company restructuring may be ended in this way and there

should be more resources for strategic investments, including R&D. Some firms (e.g. Zentiva) have already expressed strong interest in company R&D, which was seen as key to business success.

## **2.10. Slovenia**

### **National Framework Conditions**

The importance of technology in general and R&D in particular is recognized by the Government in the National Research and Development Programme 2001-2006, the new National Research and Development Programme 2006-2010 and the Development Strategies and is incorporated in a number of R&D related support strategies like three program lines of the Research Programme as well as of the Technology Transfer Initiative.

Moreover, additional emphasis is put on STI policy related aspects like privatization, procurement, training, financial market conditions, structure of the tax system and the IPR system to potentially foster R&D involvement of business enterprises. The quality, accessibility and outreach of the prevailing research infrastructure complement the pool of factors or policies proliferating R&D activities.

Privatization tendencies, particularly strong after 1992, led to the transformation of ownership structure and a more market and profit-oriented approach to entrepreneurship. Increasing international competition and the need to satisfy consumer wants and needs necessitated a more technology-oriented approach to business activity.

Procedures concerning public procurement contracts are set out in the Public Procurement Act 2004 and help enhance R&D engagement in case of tight cooperation between private and public sector entities on technology-related issues determined by public demand.

Training and education undoubtedly represent key aspects to R&D involvement and shortages of basic ingredients to R&D activities significantly hamper such activities. With stagnating enrollment and graduation rates, the weak Slovenian tertiary education system becomes a potential bottleneck to (high-quality) R&D involvement.

The banking sector appears inadequately developed to meet the needs for high and risky venture capital to finance R&D activities and private enterprises need to resort to company funds.

Tax credits or tax allowances are frequently applied measures to foster investments in R&D activities. Slovenia allows for the deduction of R&D expenditures and grants tax allowances to innovative companies operating in technology parks and deduction of PhD recruits' salaries during the first six months of employment. The effect of said measures are however difficult to analyze.

Protection of Intellectual Property Rights is guaranteed by the creation of the Slovenian Intellectual Property Office in 1992. Patent application is however still relatively low, partly due to high application costs and alternative strategies availed of to protect innovations.

The research infrastructure is dominated by the public research arena, predominantly engaging in basic and curiosity-driven research. Cooperation with business firms is still weak, limiting the creation and taking advantage of potential knowledge spillovers.

### **Sectoral Results**

All in all, R&D expenditures and R&D personnel increased between the mid 1990s and 2004. Total Business R&D expenditures which represent approximately 40 to 60% of overall R&D expenditures in 1994 and 2004, respectively, show an almost threefold increase from 90.4 mio. EUR in 1994 to 254.1 mio. EUR in 2004. Between 1994 and 2004, total R&D employment in the business sector steadily increased from 4,005 FTE in 1994 to 4,945 FTE in

2004. In 1994 and 2004, the sector represents 40 to 56% of overall R&D employment in terms of FTE.

All industry analyses emphasize the dominant role of in-house R&D expenditures and expenditures on acquisition of machinery/equipment. The majority of R&D expenditures are spent on applied research followed by experimental research. Only the Pharmaceutical industry reports higher R&D expenditures for experimental research as compared to applied research. Without exception, R&D expenditures are funded within the national business sector and company funds.

#### **Manufacture of Pharmaceuticals (NACE 24.4)**

Manufacture of Pharmaceuticals - a traditionally very R&D intensive industry - reports one of the highest R&D intensities in the Slovenian Manufacturing Industry of 8.84% in 2001 with remarkable increases of 19.4% between 2001 and 2003. Approximately 3.3% of national GDP are generated within this single industry alone.

While initially spending 18.9 mio. EUR on R&D-related activities in 1994, the industry reports a sixfold increase in expenditures between 1994 and 2004 with 104.6 mio. EUR in 2004. Among the industries considered, the Pharmaceuticals industry has the highest share of industry R&D expenditures to total Business R&D expenditures with 20.9% in 1994 and even 41.1% in 2004. Starting from 391 employees in R&D-related activities in 1994 (in terms of FTE), the industry doubled R&D-related employment to 758 in 2004. In 1994, the industry employed approximately 10% of overall Business R&D personnel, while its employment share increased to 15% in 2004. Among the four industries considered, the small Pharmaceuticals industry represents the most important employer of Business sector R&D personnel.

After 1999, industry R&D expenditures for applied and experimental research towards new product developments experienced remarkable expansions. The industry is dominated by two big generic producers which spend approximately 10% of their annual sales on R&D activities but do not actively engage in R&D cooperation activities. The vast number of medium sized and small firms serves to render input generation or output distribution services to the two key business players. Given the nature of the industry output as well as for reasons of competitiveness, profitability and survival, continuous R&D activities and implementation of new of modified products are key success factors and technological change becomes a supply-side driven phenomenon. A positive correlation between R&D involvement (proxied by R&D expenditures) and the reported export rate is apparent for all interviewed enterprises. Exposure to international competition necessitates a technology-based differentiation strategy and therefore fosters R&D activities.

#### **Manufacture of Machinery and Equipment (NACE 29)**

Manufacture of Machinery and Equipment which experienced tremendous increases in R&D intensity of 22.5% between 2001 and 2003 generates approximately 2% of national GDP.

With respect to industry R&D expenditures, a threefold increase is observable between 1994 and 2004, with 3.8 mio. EUR in 1994 and 14.1 Mio EUR in 2004. In 1994, 4.25% of overall Business R&D expenditures emerged from this particular industry. Between 1994 and 2004, the percentage contribution only slightly increased by 1.3 percentage points. With a dramatic drop observable in 2003, the industry's R&D personnel only negligibly grew between 1994 and 2004 from 260 in 1994 to 266 R&D employees in 2004. In the period under consideration, the share of industry R&D personnel to overall Business R&D personnel dropped by over one percentage point.

The industry is particularly active in the field of applied research to foster commercialization of product or process developments and sources its funds from within the business sector from company funds. R&D activities are concentrated in a small number of big enterprises with

strong export-orientation and abundance in financial and human resources. Said inputs represent key success factors for the generation and commercialization of new product and process developments. Scientifically motivated R&D cooperation seems to be of minor importance for R&D activities while cooperation with customers and competitors are regarded vital vehicles for R&D involvement. Suppliers are also considered important partners in R&D co-operation projects, provided they managed to develop own technological capabilities. High taxes as well as legal regulations are considered significant factors hampering R&D activities.

### **Manufacture of Electrical Machinery and Apparatus (NACE 31)**

Manufacture of Electrical Machinery and Apparatus reports remarkable increases of R&D intensity of 17.7% between 2001 and 2003. Approximately 1.3% of national GDP stem from this particular industry.

With its significant slump in R&D expenditures in 1997 and slow recovery thereafter, the industry reports an increase of R&D expenditures from 10.9 mio. EUR in 1994 to only 15.8 mio. EUR in 2004. Until 2004, R&D expenditures did not reach the pre-slump level of 16.9 mio. EUR. With respect to R&D employment, the industry experienced a dramatic drop in 1997 and reports 587 employees (in FTE) in 1994 and only 422 employees in 2004. Until 2004, R&D employment did not reach the pre-slump level of 660 employees. While the industry represented a prime employer in 1994 with approximately 15% of all business R&D personnel employed in respective industry, its dominance vanished to about 9% in 2004.

The majority of R&D expenditures are used for applied research for sake of commercialization. Industry output represents production inputs for other industries – particularly the automobile industry.

Customer needs are important sources of new product and process developments and internationally increasing competition, - particularly from China and India -, represent key factors fostering R&D involvement. R&D co-operations with local or foreign customers or producers as well as with academia and public research organizations are widespread strategies. Increasing tax-burden levied on employees renders R&D an increasingly difficult and expensive activity, hence financing of R&D activities is of crucial importance. Additionally, insufficient human resource potentials are considered deterrents to R&D involvement.

### **Manufacture of Medicine, Precision and Optical Instruments (NACE 33)**

In terms of increases in R&D intensity, Manufacture of Medicine, Precision and Optical Instruments outperforms the other industries considered and reports the most significant and dramatic increase of 27% between 2001 and 2003. Its contribution to national GDP is however relatively low with 0.7% only.

Starting from 2.7 mio. EUR in 1994, industry R&D expenditures show a sixfold increase by 2004 to 12.2 mio. EUR. Its share of industry to total Business R&D expenditures almost doubled between 1994 and 2004. In the same period, the industry experienced a tremendous surge in 1997, followed by rather stable employment figures thereafter and more than doubled its R&D-related employment from 141 employees in 1994 and to 344 in 2004. While the industry initially employed 3.5% of overall Business sector R&D personnel in 1994, R&D employment increased to approximately 7% of overall Business sector R&D employment.

The necessity to commercialize products and processes renders applied research the most important R&D activity so that overall industry R&D expenditures are strongly dominated by in-house expenditures on applied and experimental research. The majority of R&D funding stems from within the business sector and is dominated by company funds.

International competition and the need to withstand its growing intensity, paired with information on consumer needs and the availability of human resources for R&D activities are seen to positively affect overall R&D involvement. Growing R&D costs, particularly determined by

growing costs of R&D personnel, are increasingly viewed as hampering factors to R&D involvement in Slovenia.

### 3. Sectoral Synthesis

#### 3.1. Motor vehicles and related Industries<sup>14</sup>

Motor vehicle production is classified under NACE 34. However, the focus on one NACE sector only does not completely reflect the whole picture of the automotive industry. A very wide range of products are used to assemble a motor vehicle – practically all industrial sectors supply the automotive industry –, and thus readily available statistics are usually too narrow in terms of coverage. In other words, quite a few automotive suppliers are classified as leather, rubber, plastics, paint, glass, cable or metal producing and processing companies, foundries, electrical and electronics companies, etc. We still need statistical data, and hence a number of sectors are closely related to the motor vehicle industry:

- manufacture of motor vehicles (NACE 34.10);
- manufacture of bodies (coachwork) for motor vehicles (NACE 34.20),
- manufacture of parts and accessories for motor vehicles and their engines (NACE 34.30);
- manufacture of electrical equipment for engines and vehicles (NACE 31.61);
- manufacture of rubber tyres and tubes (NACE 25.11).

Below, the development of the NACE 34 sector (Manufacturing of motor vehicles, trailers and semi-trailers) and its R&D dynamics will be analysed in the selected NMSs. Furthermore, manufacture of electrical equipment for engines and vehicles (NACE 31.61) and manufacturing of rubber and plastic parts (NACE 25) are considered as related industries.

The sector of car manufacturing was in focus of the national research teams in Czech Republic, Hungary, Poland and Slovakia. As manufacture of rubber and plastic parts (NACE 25) is related to the automotive sector, the sector helps to extend the value chain by producing tyres within the countries. Some information on R&D in the tyre industry in the Czech Republic and Slovakia is provided. Furthermore, in the Hungarian sectoral case study Manufacture of electrical equipment for engines and vehicles (NACE 31.61) is also included.

##### 3.1.1. Pattern of R&D

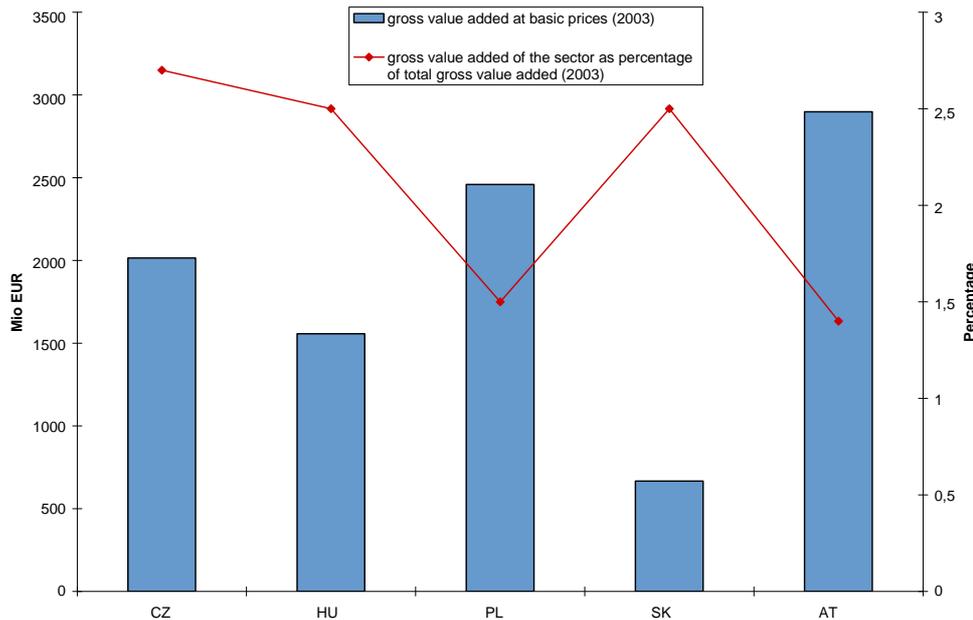
There is a big difference in the importance of the automotive sector in the national economies in terms of value added. The share of the sector in the whole economy is between 1.5% and 2.7% in terms of value added and will increase in the future (especially in Slovakia) (see Figure 1). The share of private R&D expenditure also varies significantly between countries.

In the Czech Republic, the automotive sector contributed 2 bn. EUR or 2.7% to the gross value added of the economy and 13% to the gross value added of the manufacturing industry in 2004. In the same year 7% of Czech employees worked in the sector. The relative importance of the sector is 2.5% in Hungary and Slovakia, that is, the same level as in the Czech Republic. Only in Poland the sector is less important as it contributes 1.5% to the national gross value added. In absolute terms, the value added is still below that of Austria, a small state in the EU.

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<sup>14</sup> This section has benefited from the analysis of the country reports by A Havas, presented at the validation workshop held in May 2006.

**Figure 1: Value added by the automotive sector (NACE 34) – at basic prices and as percentage of total value added in the countries**



Source: EUROSTAT

The **Czech Republic** has the highest figures among the NMSs in terms of nominal private R&D expenditures and R&D staff employed in the automotive industry. The sector's R&D expenditure was around 170 mio. EUR, with slightly decreasing expenditures from 2002-2003 in Euro-terms, or stagnation when it is considered in local currency. This decrease cannot be considered as a trend as R&D expenditures (in Euros) remained relatively stable relative to GDP from 2001 to 2004 (see Table 2). R&D expenditure as a percentage of GDP is above the EU average in NACE 34 in the Czech Republic. In Hungary, Poland and Slovakia it is below that level. But, unlike in the Czech Republic, growth rates in R&D expenditure in these countries were between 54% and 114% over a two to four year period.

From 2002 to 2004 only Poland shows a significant increase in R&D personnel of more than one third. Although such a dramatic increase always requires prudent interpretation, FDI investment played an important role for the increase due to the establishment of new R&D centres (like the ones by Delphi and TRW). For Slovakia no data are available due to confidentiality restrictions. In contrast, the absolute level of R&D personnel in NACE 34 stayed more or less stable in the Czech Republic and in Hungary.

In the former Czechoslovakia, at the end of the 1980s, almost all automotive companies had their own R&D department. This radically changed after 1990. The situation was heavily influenced by the way these companies have been privatised. The most important and most successful privatisation in the Czech automotive industry was the one of Skoda Auto. Due to the investment by VW, the number of R&D employees increased from approx. 600 in 1991 to 1420 in 2005. Many other privatised companies were not as lucky as Skoda Auto, and they were forced to either close down or considerably restrict their own R&D activities.

It is likely that R&D investment will also rise in other firms within the sector, with increasing expenditures in both investment and human resources. First, only manufacturing sites were built, now also R&D centres are being established. For instance, Siemens Automotive Systems Ltd., Robert Bosch Ltd. and Behr Czech Ltd. are among the companies that decided to establish R&D centres in 2004. New automotive product development projects are also being more and more secured by R&D centres in the Czech Republic even for the foreign headquarters.

Data for the tyre industry are only available at the aggregate level, NACE 25. R&D expenditures in NACE 25 are quite low and the number of R&D employees has been stagnating during the last 5 years. Compared to the situation in 1995, significantly less R&D personnel were employed in this sector in the Czech Republic. R&D employment (FTE) also fell in Slovakia, from 171 in 200 to 140 in 2004. Increasing tyre production might help raise R&D employment again in both countries.

In **Hungary** NACE sector 31.61 was significantly below the national average of the manufacturing industry in 2000-2001, if R&D-intensity is measured by the share of R&D expenditures in value added, but closer to that average when R&D employment is taken as a measure. This simple exercise suggests that R&D expenditures per R&D employees were much lower in this sub-sector than the national average in the given period. One should also bear in mind, however, that data are missing from the EUROSTAT database for 2002-2004, and this sub-sector has been selected for our study exactly for the high growth rate of R&D expenditures: almost a 7-times higher amount in 2004 compared to 2001. Thus, available data do not permit to draw firm conclusions as far as the R&D-intensity of this sector is concerned.

NACE 34.1 presents a similar case: lower R&D-intensity than the manufacturing industry average when it is measured in expenditures, but a higher one when employment is taken into account.

In contrast, NACE 34.3 is way above the national manufacturing average (2 and 5 times higher intensity), if either measure is taken. In this case, both CSO and EUROSTAT data point to the same conclusions. Given the strong performance of this sub-sector, the automotive industry at a 2-digit level is close to the Hungarian manufacturing industry average when R&D expenditures are taken into account, and 4 times above that average, if employment figures are taken as an indicator.

In **Poland**, the share of R&D expenditures in transport equipment manufactures at current costs is much bigger than the total industry average. Much more R&D activity were out-sourced (to foreign specialised laboratories) or spent on salaries and other current costs. Capital expenditures for R&D are less than in the total industry average. The relation between R&D expenditures and total sales has reached 0.2% in 2003 and 2004 (despite a dynamic 55% increase of expenditures on R&D), what is still far from the developed countries' average.

The number of R&D employees increased by about 48% in 2004 compared to 2003, that is, from 786 to 1,168. Especially the number of researchers was almost doubled from 406 to 786. This increase gives some indication that the demand for R&D increases in the sector.

In **Slovakia**, the low numbers of organisations reporting R&D in manufacture of motor vehicles (1 organisation) and manufacture of other transport equipment (3 organisations) by 2004 prevented publishing data on R&D employment and expenditures in the industry. The 2001-2003 CIS 3 Survey enables a glimpse on the issue. Firms in the sector reported R&D investments of 5.1 mio. EUR. The sector ranked to the most R&D intensive in Slovakia (3 times of the country average).

**Table 2: Overview of R&D intensity, increases in R&D intensity, and sectoral share in national GDP**

Country	NACE code	Sector	R&D intensity private R&D investment as % of sectoral GDP (2003 or 2004)	Increase in R&D intensity (%)	Sectoral GDP as % of national GDP (2003 or 2004)
Czech Republic	34	Manufacture of motor vehicles, trailers and semi-trailers	8.8%	5% (stable) (2001-2004)	2.7%
	31	Manufacture of electrical machinery and apparatus n.e.c.	1.8%	104% (2001-2004)	1.8%
	25	Manufacture of rubber and plastic products	0.9%	91% (2001-2004)	1.6%
Hungary	34.3	Manufacture of parts and accessories for motor vehicles and their engines	2.8%	114% (2001-2003)	0.8%
	31	Manufacture of other electric equipment	3.5%	54% (2001-2003)	0.3%
Poland	34	Manufacture of motor vehicles, trailers and semi-trailers	1.3%	55% (2003-2004)	1.3%
Slovakia	34	Manufacture of motor vehicles, trailers and semi-trailers	1.7%		2.2%
	25	Manufacture of rubber and plastic products	1.1%	10% (1998-2004)	1%

Sources: EUROSTAT and National Statistical Offices

### 3.1.2. Determinants of R&D investment

The automotive sector is a dynamic sector in many NMSs, albeit with differing levels of R&D intensity. The development of the automotive sector over the last years took country-specific paths due to individual historical determinants. The Czech Republic and Hungary had a long tradition in car manufacturing before World War 2, but these specialisation patterns changed considerably due to the division of labour between the member states of Council of Mutual Economic Assistance (CMEA), which comprised a market of 400 million people. As an example, the Soviet-Hungarian specialisation agreement from 1964 stipulated that Hungary would specialise in producing buses for the entire CMEA. Skoda was practically the only producer of cars in the NMSs with its own R&D unit. All other car manufacturers produced cars with licences from western companies. These historical developments are, to some extent, still perceivable in the structures of the sector.<sup>15</sup>

<sup>15</sup> For more details on the history of the automotive industry in Central European countries, including recent developments, see e.g. Havas [2000a], [2000b], Pavlinek, [2002a], [2002b], [2003], [2005]

Today, two main arguments for investors in this sector are cost arguments vis-à-vis the old member states of the EU and the emerging opportunities to get a foot into the enlarged European market. The first argument is true for all investors; the second argument is mainly relevant for manufacturers from Asia. In most cases investments follow either a low end / high volume strategy or a high end / low volume strategy. Other arguments are the “hungry customers” in the NMSs, geographic proximity and a “test-bed” functions for organisational innovations. (Havas [2000a]).

The structure of the automotive industry is organised hierarchically: at the top of the “pyramid” there are the vehicle manufacturers, supported by suppliers structured in three tiers. The tasks of first tier suppliers (T1) include not only manufacturing of certain parts and components but product design as well, either together with their assemblers or on their own.<sup>16</sup> As for manufacturing of a given part, though, usually more than one supplier is chosen, and hence several suppliers are competing for orders. First-tier suppliers have also built their network, usually consisting of 20-60 firms. These second-tier suppliers, in turn, rely on thousands of small and medium-sized enterprises, producing basically simple, labour-intensive products given their wage advantages compared to larger firms. T1 suppliers provide training for their network on quality assurance techniques, just-in-time logistics, as well as on technological developments, and assist and check the introduction of various technological, organisational and managerial organisations.

This general organisational pattern of the industry is having significant impacts in the NMSs. A number of foreign-owned T1 suppliers have also set up plants in the NMSs, either via green-field plants, or by taking over domestic firms. Most of the domestic companies, however, are T2 and T3 suppliers, with some exceptions.

**Foreign direct investment** is the main determinant of the expansion of the sector. Investments are either secured by take-over of existing firms or in some cases by joint ventures. Investments are either brown-field or green-field types of investments. Asian car companies seem to follow their customers: they establish new factories in the NMSs which allows them to sell their cars on a growing market in the NMSs, and get closer to the EU-15 markets. As these firms can draw upon their Asian networks of suppliers only to a limited extent (given the geographical distance, or as in the case of Slovakia are hindered to do so by national interest groups), local suppliers in the NMSs have the business opportunity to expand. Some of their former Asian suppliers do follow these car companies in Central Europe, too, setting up subsidiaries, and thus eliminating the disadvantages of geographical distance.

Important FDI projects have been for instance in the Czech Republic the acquisition of Skoda by VW, while in Hungary Suzuki, General Motors and Audi established their operations by green-field investments. Fiat and Daewoo took over Polish firms and General Motors set up a green-field investment in Poland. PSA Peugeot Citroen and Hyundai Kia are setting up green-field investments in Slovakia.

In **Slovakia**, automotive industry has been dominated by Volkswagen and its suppliers. Slovak suppliers to the automobile industry have managed, within a relatively short period of time, to apply European standards of quality, productivity, logistics, environment and labour. There are more than 260 automotive suppliers and subcontractors in Slovakia. The top ten include: Bosch, Delphi, Johnson Controls, Visteon, Lear, Magna, Valeo, TRW Automotive and Dana. The sector contributed 19% to the total merchandise exports in 2002 and employed more than 25 thousand people (ILO [2005]).

Slovakia currently manufactures over 250 thousand cars per year. In 2003 and early 2004 both PSA Peugeot Citroen and Hyundai-Kia announced their plans to build large final assembly plants in Slovakia. This investment will nearly triple automotive output by the end of the

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<sup>16</sup> In the latter case they might well work with other firms and various R&D institutes, of course. The point is, that the assembler only defines the main parameters of a given part or component, e.g. its size and required technical performance, and leaves the whole design process to its supplier.

decade and remains the key driver of the Slovak economy. These developments may as well lead to an increase in R&D intensity in the future.

The automotive industry is one of the most important branches of the **Czech** economy, too. Similarly, as in other advanced countries, it very noticeably influences trade balance: 85% of cars were exported, making up for 21% of total Czech exports (Havas [2006]). The sector attracts foreign investments and improves the situation on the local labour market (> 80 thousand jobs (ILO [2005]). After 1989 the Czech automotive industry – as well as other branches of the economy – went through a long and important restructuring period. Today, the sector is fully comparable with those in many advanced countries, and controlled by private enterprises. Most of the companies are managed by strong foreign owners, predominantly from Germany. Under such conditions the continuing economic improvement is apparent not only in the individual companies, but also in the whole automotive branch.

The **Hungarian** automotive sector comprises around 36 thousand employees and is an important factor in the trade balance: 17% of the economy's total merchandise exports in 2002. (ILO [2005]). After half-a-century of CMEA-wide division of labour, car production has re-emerged in Hungary in the early 1990s. Suppliers have also invested heavily in Hungary. Moreover, their motivation has not been simply to follow car assemblers. On the contrary, to serve them from nearby plants is only a minor part of the explanation. Their principal reason for setting up subsidiaries in Hungary has been cost-cutting. The only major local clients for them are not car assemblers but the engine and gear box manufacturing plants of Audi, GM Opel and ZF, hence the vast majority of their output is exported and is attributed to the sub-sector NACE 34.3.

At present, in **Poland** there are about 345 producers with 92.5 thousand employees in companies of manufacture of transport equipment. The main producers of passenger cars and vans in Poland are Fiat Auto Poland S.A. in Bielsko-Biala, FSO S.A. in Warsaw, Opel Polska in Gliwice Sp. z o.o., Volkswagen Poznan Sp. z o.o. in Poznan and Intrall in Lublin. The main producers of trucks and buses and coaches in Poland are: MAN–Star Truck Sp. z o.o. in Starachowice, Zakłady Samochodowe JELCZ S.A. in Jelcz-Laskowice, Autosan S.A. in Sanok, Solaris Bus & Coach Sp. z o.o. w Bolechowie, Solbus Sp. z o.o. w Solcu Kujawskim, MAN Pojazdy Użytkowe Polska Sp. z o.o. in Poznan, Volvo Poland Sp. z o.o. in Wroclaw and Scania-Kapena Sp. z o.o. in Słupsk. Delphi and TRW are the two first enterprises in the sector setting up their own R&D units in Poland.

Production in **manufacture of rubber and plastic products** is to a large extent related to the rapidly developing car industries in Slovakia, the Czech Republic and elsewhere in Central and Eastern Europe. Tyres, vibration control parts and plastic car components are main products in this sector in Slovakia. The sector is one of the most dynamic industries in the Czech manufacturing sector since the second half of the 1990s. Its position in the manufacturing structure has significantly improved. This enormous increase has resulted from a close linkage to the rapidly increasing automotive sector, as well as the electrical industry, food industry and building industry that creates the core of the Czech industrial structure today. The 2000-2004 was a period of rapid growth in the sector. Volume of sales, total value added and value added per employee doubled. R&D in NACE 25 is mainly driven by foreign companies operating in the Czech market, enormous growth of automotive and electrical machinery and a growing foreign demand. In Slovakia, R&D is dominated by one large domestic firm.

### 3.1.3. Framework conditions

Framework conditions that can have an impact on R&D investment are of varying influence on R&D intensities. Unlike in the pharmaceutical sector where environmental regulations or quality standards play a central role, the automotive industry is less influenced by national or EU regulations, apart from regulations on emission – but that mainly affect the parent firms, who are in charge of designing engines. The car industry also has to implement the REACH legislative on chemical products. Chemical industry is one of major suppliers for manufacture of cars. Estimates by the Slovak Ministry of Economy identify costs of some 70 mio. EUR in

the next seven years to implement REACH. But given total turnover of 5.8 bn. EUR (2004), the REACH costs should not endanger competitiveness of the car industry in Slovakia.

Apart from legal regulations, standardisation plays a role for the sectoral production system. Standardisation is very much related to the tier-system. This normally supports enterprises which are able to influence standardisation. Moreover, FDI-based intra-firm knowledge spill-over help to reduce related R&D efforts to a minimum.

Tax incentives or tax credits are another type of rather indirect RTDI policy measures which are not specifically designed for the sector in question, but might be an incentive for MNCs to investigate the capacities for R&D activities in the NMSs. The impact of such measures has not yet been evaluated.

The public support in setting up technology parks (purchase of land, arranging administrative procedures, building basic infrastructure) which will be also subsidised by EU structural funds in the future might be an additional incentive to attract R&D units.

### **Human resources**

The availability of highly qualified R&D personnel seems to be an ever increasingly important factor for the expansion of R&D units in the NMSs.

The productivity growth within the NACE 34 sector in the Czech Republic is higher than the labour costs growth, which is important for attracting FDI and keeping the sector competitive against other countries. The only problem with the human resources in the Czech Republic is to find the right people for the right job due to the fact that more and more automotive companies are setting up their factories in the Czech Republic.

Some recently published labour market analyses point out the lack of suitably qualified personnel for R&D. Lack of qualified employees and university graduates with technical background was one of the reasons which led Skoda Auto towards the decision to build the university campus "Na Karmeli".

### **Research infrastructure**

Universities focused on transport and engineering play a very important role for future success of the Czech automotive R&D. They educate qualified staff and co-operate with the automotive companies on various R&D projects, respectively carry out research according to the industry customer requests. So far there is a communication gap among universities and their engagement into specific research tasks. There are many obstacles in co-operation among companies and R&D institutions, such as the focus of the universities on academic research instead of research with applicable results, administrative barriers, etc. Moreover, universities are also often criticised for insufficient reactions regarding specific company's requests concerning graduates' knowledge.

#### **3.1.4. Impact of R&D**

The direct impact of R&D activities is reported in only very rare cases. Although on a very high aggregated level, studies (e.g. as cited by ILO 2005) show a clear correlation between R&D activities and economic performance, it is hard to trace and evaluate the impact of private R&D in the automotive sector.

Doubtless, there is a large impact of technologies and processes that were brought to the NMSs by FDI. Productivity rates are rising in the sector in most countries which can be explained by intra-firm knowledge transfer. At the firm level, the diffusion of new management methods and organisational techniques can be identified, which is also caused by the strong influence of FDI.

Another impact is the growth of the supplier industry. One reason for growth is FDI by Asian firms that want to get a local base inside the EU. They much more rely on establishing new links with local suppliers in order to comply with the local content rules, than the European firms that can more easily stick with their existing suppliers, as the EU local content is not an issue for them (Havas 2000a). It is yet to be seen if the recent investment of Hyundai-Kia would confirm this observation or it would have to be amended. In any case, indigenous suppliers are likely to be “forced” to step up their R&D efforts – in a number of cases by setting up R&D units from the scratch, and in all cases via more intense co-operation with universities and R&D institutes – to be able to compete in the global market. Most likely R&D will play a role in the efforts to extend the value chain in the car manufacturing within the NMSs. One should not overestimate, though, the potential of R&D-induced growth in low- or mid-tech suppliers industries.

Innovation, however, should play a crucial role in enhancing indigenous suppliers’ competitiveness, in order to secure their market share, and thus other sources of knowledge and innovation need to be exploited. Absorptive capabilities and innovation management skills, hence, should be considerably strengthened at a firm level. Carefully designed policies can certainly assist this upgrading and also need to promote the development of the wider institutional framework such as communication and networking among firms (e.g. large businesses and SMEs, among SMEs), as well as academia-industry co-operation, and ultimately the strengthening of clusters.

### **3.2. Pharmaceutical Industries**

In the following chapter the development of the pharmaceutical sector (NACE 24.4) and its R&D dynamics in selected NMSs will be analysed. The pharmaceutical sector is one of the most R&D intensive and dynamic sectors per se and thus an interesting case study. The sector has been studied by the national research teams in Poland, Hungary and Slovenia. Moreover, the chemical sector (NACE 24) has been analysed in Latvia and Slovakia which also delivers some fragmented information about the pharmaceutical sector.

In Table 3, the R&D intensity of the pharmaceutical sector (NACE 24.4) or of the aggregated NACE 24 is listed, as well as the relative increase over a certain period of time. This listing gives an overview of the importance of R&D in the sector in the various countries. R&D intensity is highest in Hungary (19.2%), followed by Slovenia (8.8%) which also shows an increase in intensity over a three year period from 2001 to 2003. Furthermore the share of the sectoral GDP as a percentage of the national GDP is given to indicate the importance of the sector in the country. It shows that the pharmaceutical sector has the highest share in the Slovenien economy (3.3%) and a share below 1% in the other countries. Given the limited data, it can be said that pharmaceutical sector plays a large role in private R&D only in Slovenia and to some extent (with significantly lower importance of the sector in the national economy) in Hungary.

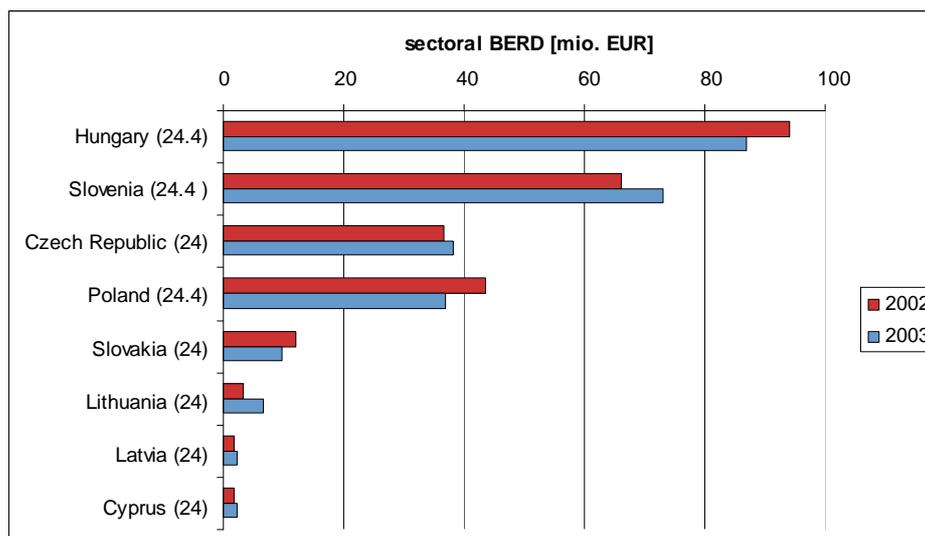
#### **3.2.1. Pattern of R&D**

The transformation of the pharmaceutical sector has been dominated by the privatisation of former state own large enterprises and by FDI. This led to a restructuring of R&D labs within larger organisations. In some countries restructuring lead to a concentration of R&D in fewer R&D sites. This, for instance has happened in Hungary in the last few years. However, in general, the number of firms has not changed significantly. The number of firms slightly diminished in Hungary in Poland, while it slightly grew in Slovakia.

For international country comparison it is enlightening to compare R&D expenditure in absolute monetary terms. The absolute figures of R&D expenditure (see Figure 2) show that Hungary and Slovenia are the most important R&D performers in the NMSs competing on the global market. In the much larger economy of Poland and in the Czech Republic enterprises invest only half the amount that is spent by the MNCs in Hungary. The other countries con-

sidered in the sectoral comparison are not easily to be perceived as sites for private R&D investment.

**Figure 2: R&D expenditure in pharmaceutical industry or the chemical industry in NMSs (in mio. EUR)**



Source: EUROSTAT

Apart from Slovenia and Hungary, the National Innovation Systems are not very much oriented towards the pharmaceutical sector. The data on R&D personnel show that the Slovenian pharmaceutical sector is more capital intensive than in Hungary. In 2002, 25% of the R&D personnel in Hungary were spending 35% of national BERD, whereas 15% of Slovenia's R&D personnel were spending 30% of national BERD. One reason might be that labour productivity in Slovenia is higher than in Hungary, but it might also be explained by country specific structures between the enterprises. The temporal comparison shows that in smaller countries larger changes in R&D investment and employment can be observed. Again, it is not easy to estimate the share of the pharmaceutical sector in the aggregated figures at NACE two-digit level.

Over the last 10 years the pharmaceutical sector has been growing with respect to total size (in terms of sales and value added). This holds true for R&D expenditures and R&D employees in most countries studied here. Some countries showed a drawback (e.g. Latvia in 1999) but have recovered recently. A more general decline in economic activity in the chemical industry can be observed in Slovakia.

The following trends in pattern of R&D can be observed in the three countries studied with available data for the NACE three-digit level:

**Hungary's** pharmaceutical sector has grown faster than the entire chemical sector in the last few years. It is the most R&D intensive sector in Hungary. Between 2001 and 2003, R&D expenditures grew about 20% annually. Total sales and value added also grew remarkably between 1997 and 2004. The growth was fuelled by massive increases in productivity, which led to a decreased number of employees in this period, too.

The pharmaceutical sector in **Poland** invested increasingly in R&D between 1999 and 2004, which is in complete contrast to the general R&D investment trend of the whole industry during that period. The number of employees grew in the same period. Although, the number of R&D-performing units decreased in the same period.

The development in R&D performance in **Slovenia's** pharmaceutical sector is the one with the most significant increases. The R&D expenditures almost sevenfold between 1992 and 2004, even though only two firms are active in R&D. Both firms, namely Krka and Lek, are subsidiaries of MNC.

For five more countries at least some pharmaceutical specific pattern of R&D can be drawn:

For **Cyprus** data are only available at NACE two digit level. The employment related to R&D expenditure in the chemical sector reached 1.3 mio. EUR in 2003 while the capital expenditure was 573 thousand EUR. The main type of research activity that has been observed is mainly experimental research, followed by applied research. However no information is available on the specificities of the pharmaceutical sector.

The R&D expenditures in the **Czech** chemical industry significantly reached 50 mio. EUR in 2004. Expenditures were decreasing in the first half of the 1990s due to the privatisation, however, during the period 1995-2004 it doubled and a considerable increase was evident particularly in 2004. The pharmaceutical industry is an important part of the chemical sector in the Czech Republic. The intramural private R&D expenditures in the pharmaceutical industry (NACE 24.4) amounted to almost 62% of R&D expenditures in NACE 24 and the share of NACE 24.4 increased significantly in recent years (49% in 2003).

In **Latvia**, the chemical sector has recovered after a decline in 1999. The turnover in 2003 was about the same as in 1997, half of which came from the pharmaceutical sector. Over the last few years, R&D expenditure grew faster than the sectors turnover, and the share of R&D in sectoral GDP rose to 1.9% (2003). Like in most other NMSs, the sector is dominated by a few large companies, which are the ones performing most R&D.

As in many other countries, **Lithuania's** chemical industry is among the largest R&D investors in the country. The sectors R&D investments comprised 29.2% of total BERD in 2003. It employed 77 researchers. The development of the pharmaceutical industry is very weak. Lithuania exports (30% of sales) are directed towards eastern markets. No information is available how many of the 77 researchers in the sector are working in the pharmaceutical industry.

**Slovakia's** chemical sector is the oldest one, though; the pharmaceutical sector only represents a small part of the NACE 24 category. Among the 10 largest chemical firms only one pharmaceutical firm is represented. The pharmaceutical branch is thus underrepresented within the chemical sector. As mentioned before, the chemical sector had some problems in the past with a decline in value added. As a consequence R&D expenditures as well as R&D employment declined.

**Table 3: Overview of R&D intensity, increases in R&D intensity, and sectoral share in national GDP**

Country	NACE code	Sector	R&D intensity private R&D investment as % of sectoral GDP (2003 or 2004)	Increase in R&D intensity (%)	Sectoral GDP as % of national GDP (2003 or 2004)
Cyprus	24	Manufacture of Chemicals and Chemical Products	3.8%	113% (2001-2003)	0.5%
Czech Republic	24	Manufacture of chemicals and chemical products	4.6%	65% (2001-2004)	1.4%
Hungary	24.4	Manufacture of pharmaceuticals, medicinal chemicals and botanic products	19.3%	-5% (2001-2003)	0.5%
Latvia	24	Manufacture of chemicals and chemical products	1.9%	50% (2001-2003)	0.6%
Lithuania	24	Manufacture of chemicals and chemical products	5.3%	974% (2002-2003)	1.0%
Poland	24.4	Manufacture of pharmaceuticals, medicinal chemicals and botanic products	n.a.	39% (2003-2004)	n.a.
Slovakia	24	Manufacture of chemicals, chemical products and man-made fibres	1.1%	- <sup>17</sup>	0.8%
Slovenia	24.4	Manufacture of Pharmaceuticals	8.8%	19% (2001-2003)	3.3%

### 3.2.2. Determinants of R&D investments

The success of FDI is the most decisive factor of the development of the pharmaceutical sector and of R&D investments in the NMSs. On the one hand, R&D investment is depending on the general framework conditions such as the socio-political environment, and on the other hand, it is depending on the capacity and potential of the pharmaceutical firms, which had to deal with the transformation from state-owned into privately owned organisations.

The short list of key firms in each country confirms the strong concentration of the sector in the NMSs. In most countries the largest firms are now subsidiaries of foreign MNCs. The Hungarian sector, for instance, is now nearly totally influenced by foreign MNCs. About 80% of the industry is owned by foreign investors. However, in Slovenia, for instance, the largest firm is still partly national as it span of from a merger of a Czech and Slovakian firm.

<sup>17</sup> Unknown, because of the individual data protection.

In general, as can be observed, for instance, in Hungary, FDIs have opened the doors for international co-operations via the networks of the multi-national parent companies. The foreign owners have restructured the R&D system, and reduced the number of R&D projects. At the same time the product range was also narrowed. Hungarian R&D affiliates thus had to specialise in certain fields of product development and manufacturing. As a critical side effect, this also limits the co-operation with domestic universities. Co-operation was mainly taking place in the field of analytical testing, which is now reduced due to the specialisation of the industry.

In the last decades the R&D strategy of the majority of pharmaceutical firms in the NMSs was mainly based on the production of generic products. Following this business and innovation strategy most pharmaceutical companies carrying out applied R&D, even though, the development of new drugs and the ability to develop or discover new molecules is becoming increasingly important to remain competitive in the long run. Cases in Hungary, Slovakia and the Czech Republic show that firms were not only successful in improving production processes but also in mastering the product innovation challenge. In one of the company case studies, the firm (anonymous) invests 8.6% of its turnover in R&D. It serves as an example of a highly successful pharmaceutical company, which develops original drug molecules and generic products.

Like in other countries, Polish companies' prime strategy was and still is the development of generic drugs. In contrast to other industrial sectors, privatisation in the pharmaceutical sector has gone slower in the last few years, which is certainly the reason why the pharmaceutical sector has still problems in its performance. In general, the companies have problems with quality management (safety). For instance, it is still not possible to export to the EU market, because of the lack of documentation of quality procedures. Thus, most products are sold to countries with lower standards such as in Eastern Europe and the Middle East. There seems to be a need for further foreign capital in the future to improve R&D capabilities and to master the quality level standards required internationally.

A case of a dynamic pharmaceutical firm which masters the transition characterised by restructuring and privatisation is Zentiva Hlohovec. Zentiva Hlohovec is the fourth largest Slovakian firm in the chemical sector with an R&D ratio of 4.1%. It is a merger of the former Slovakian Slovafarma and the Czech Leciva and is now the biggest Central and Eastern European producer of pharmaceuticals. It is successfully listed in the Prague Stock exchange and has a newly developed portfolio of 'branded generics'. Some of the R&D efforts formerly carried out in Slovakia have been now transferred to the headquarters in Prague. The company has developed new products (new generic molecules) and built up R&D, manufacturing and marketing capabilities successfully. The firm sells its products mainly to Central European countries and the Russian Federation. At the end of 2005 240 researchers were employed. In contrast to problems with regulation mentioned by other firms, Zentiva has strong and good relationships with the regulatory authorities in each of the company's core markets.

Most drugs are mainly developed for large or global markets. However, specific national market demand conditions, e.g. by close co-operations with hospitals, universities, key scientists, etc. could create some niche markets and thus help to explore national competitive advantages. However, the strength of domestic markets could not be identified as an important factor in the pharmaceutical sector. Thus, favourable internal market conditions have not been determinants or enabling factors for a dynamic development of the pharmaceutical sector.

Finally, start-up activities are another important determinant of R&D dynamics. Even though the data sources are limited and assumptions have to be made with some prudence, start-ups have generally been very weak across the countries studied. In all countries the pharmaceutical sector is dominated by a few large (foreign) firms. Start-up activities in this sector are very challenging due to the high risk and the huge amount of capital required.

### 3.2.3. Framework conditions

Regulations, in particular patent rights and the registration of new drugs are important factors for the development of the pharmaceutical sector in the NMSs. In order to master these challenges, the pharmaceutical companies had to improve their quality management procedures. The REACH (Registration, Evaluation and Authorisation of Chemicals) program, is however, considered as hindering the R&D and innovation process. The implementation of REACH has been a major challenge for the development of the sector, as, for instance stressed by the Slovak report. The regulation might harm competitiveness in the short run, but will set incentives for innovation at the same time on the long run.

Many Polish companies were not able to cope with the demanding new conditions of the EU market, which requires quality standards that are not reached by most enterprises in the Polish industry. In general, recently introduced environmental protection regulations have hampered the development of the sector. Due to these difficulties, Poland has achieved to postpone the EU deadline until the end of 2008. Moreover, the Good Manufacturing Practice (GMP) standards are required to achieve the highest level of safety within the sector.

The importance of quality management and safety processes is also stressed in a company case study in Slovakia. The case study provides an example of a company that has successfully used the European Mutual Recognition Procedure (MRP) in order to gain market registration for key products (marketing authorizations) in the EU. The company is also member of the safety data processing networks and management (EudraVigilance) to maintain its high quality level.

The research infrastructure (universities and research organisations) plays a minor role in the different countries as concerns the development of the pharmaceutical sector as co-operation partner. In general, the links to the national research infrastructure seem to be rather weak in many countries. The two largest Slovenian pharmaceutical companies are engaged in the development and production of generic products but have so far hardly been linked to the national research infrastructure, e.g. via co-operations with universities. Some firms, such as the Hungarian case study firm, have even signed co-operation agreements with foreign laboratories, which was possible since the company has long experience in doing co-operation with international partners. Co-operations are generally seen as a strategy to share risk in the pharmaceutical sector, as, for instance stressed by a Hungarian firm studied.

Nevertheless, there are also some examples of firms which have successfully exploited the national research capacity. The largest Latvian pharmaceutical company, which was privatized in 1997, is now listed at the stock exchange. It has successfully introduced new products in the last years, spends about 10% of revenues in R&D and co-operates with national and foreign research institutions, hence, has mastered the transformation process. However, other Latvian companies are not engaged in co-operations with research institutes. Some historically closer links between industry and research institutes can be observed also in Lithuania, though, in particular in the area of biochemistry. There are some internationally very successful pharmaceutical companies, which specialised in niche markets. Moreover, in Lithuania some spin-off activities can be observed (biochemistry).

Thus, at the moment, the public R&D infrastructure is obviously not very favourable for pharmaceutical companies in the NMSs. The Slovakian report for instance, concludes, "R&D infrastructure in many Slovak industries reminded of technical museums rather than modern research facilities." However, at least from the perspective of some of successful companies, the general framework conditions are regarded as favourable with respect to the future development potential.

At the moment human resources seem to be the most critical hampering factors for the further development of the sector. Interviews in Latvian firms, for instance, reveal that the lack of qualified scientists hinders the further expansion of R&D activities. Potential candidates are often insufficiently qualified. Many qualified scientists go abroad (brain drain). Ageing of the

researchers is another related problem in the Baltic countries. The Hungarian study concludes: “The Company needs to have the best brains and not technicians”. To some extent this is also due to the lower attractiveness of natural sciences among students. In Latvia, however, the number of students has grown which is a good precondition for the future development. It remains un-answered here, whether or not universities will be able to train as many qualified students as demanded by the industry.

#### **3.2.4. Impact of R&D**

Due to a lack of data, fast changing framework conditions and restructuring of the sector in the last few years, a deeper assessment of a direct impact of R&D activities on economic performance is not feasible at the moment.

The assessment of the impacts of R&D is generally difficult. Most likely, increasing R&D investments have fostered growth and kept companies competitive in many cases. International investors have played a central role in that respect. In general, investments in R&D have helped to increase productivity, in particular with respect to the production of generic products. In some cases even the development of new pharmaceuticals was reported.

In some cases, firms with a long established development and competence track (not only with generic products but also newly developed molecules) were able to keep production in the country and further develop their R&D strategy. Another result of the study is that newly established firms, spin-offs and start-ups play hardly any role in the R&D performance of the NMSs.

Even though the pharmaceutical sector obviously enhanced its competitiveness in the past, in general, perspectives appear to be rather unfavourable. It remains unclear, if the sectors in all NMSs will be able to grow in the future under the given framework conditions. The main challenges will be to be innovative in terms of being able to develop new molecules, to closer cooperate with domestic research institutes, and to develop the necessary qualification of human resources to match the needs of the sector.

### III. Conclusions

#### 1 Cross-Cutting Issues

As shown by the sectoral case-studies in this project, the patterns of private R&D investment in NMSs are very heterogeneous. This heterogeneity is to a significant extent a reflection of the respective national and sectoral „R&D histories“, i.e. a result of path-dependencies. Specifically in the former communist countries, it becomes obvious that the division of specialized industries between the countries of the economic alliance is still influencing the importance of private R&D investment in the different sectors. This is most obvious in the case of the automotive industries and is still reflected in today’s economic structure and the private R&D expenditure in the sector. A significant and broadly based domestic R&D capacity has been maintained in the Czech Republic, building on the continuous presence of Skoda as a major automotive manufacturer. In other countries, industrial R&D capacities have been re-established rather recently, mostly with a very specific mission within the global R&D strategy of the mother company. Other countries like Slovenia, never had a significant share in the automotive sector, or were specialised in niches like Hungary. The heterogeneity of the sectoral case studies is also partly determined by the size of the countries. Countries like Malta or Cyprus hardly show any R&D activities. Larger countries like Poland, Czech Republic have a longer tradition in R&D activities.

Moreover, the current situation is still very much in flux; the processes of industrial transformation and integration in the global economy have not yet settled. These general observations imply that any recommendations to policy should be based on a sectorally and nationally differentiated interpretation of patterns of private R&D investment. This is consistent with the recent trend in research and innovation policy research to stress the integration of RTDI-policies into stronger industrial or sectoral policies (Malerba 2004). Although such a more differentiated perspective seems to be appropriate from a conceptual point of view, it turned out to be very difficult – at least in some countries – to underpin it with statistical data. In some countries (Malta, Cyprus, Lithuania and others) this is simply a matter of data availability, in others the interpretation of data is not unequivocal due to problems of confidentiality (e.g. SK), inappropriate international statistical standards (e.g. in services) and in the smaller NMSs it is a matter of scale of the sector (Malta, Cyprus, Lithuania, Latvia, Estonia).

In spite of this call for a differentiated and cautious interpretation of private R&D investment data, some cross-cutting observations can nevertheless be made. First of all, FDI tends to play a very significant role in many sectors (automotive, pharmaceuticals), implying a more or less tight embedding of the R&D investment in a NMSs in the overall R&D strategy of a multi-national firm. This development – while being generally perceived as very positive – has a number of double-edged impacts on the evolution of the R&D base in a country. On the one hand, foreign investment tends to contribute to the upgrading of the managerial knowledge and organisational competences as well as diffusion of new technologies. New techniques and practices are being introduced and the collaboration with local partners and suppliers allows spreading these new approaches more widely. On the other hand, the embedding in a global company’s R&D strategy often entails a narrowing of the scope of the R&D work performed in the country concerned. This, in turn, has consequences for the spectrum of R&D collaboration with domestic universities and research centres. It is also worth noting the type of R&D that is being performed by enterprises in the NMSs. It is less basic research oriented than in countries with headquarters and is much more focused towards specific niches (e.g. pharmaceuticals in Hungary), as well as adaptation-oriented in the sense that restructuring and modernisation of the economy is still taking place to a noticeable extent (e.g. R&D in financial intermediaries in Estonia). Moreover, due to the internal competition between R&D locations of a multi-national company, there is a risk that these activities may be moved else-

where, if the conditions for R&D or the overall R&D strategy of the company change. The maintenance of private sector R&D activities by way of FDI thus comes at the price of uncertainty about the sustainability of this investment. However, in the end, the extent to which R&D might become “footloose” depends on the quality and continuous improvement of the factors and conditions due to which R&D-investment were initially set up (and maintained!) in a specific location.

The sectoral case studies have shown that the reasons for foreign investment in R&D can be manifold. Of outstanding importance for foreign investment in R&D seems to be a combination of three factors: the quality of the human resource and competence base, the labour costs, and the access to local markets. The availability of highly qualified R&D personnel is widely acknowledged as strength of many NMSs, in many cases building on a long-standing industrial tradition in the respective sector (e.g. Czech automotive industry, pharmaceutical industry in Hungary and Slovenia). However, growing R&D investment be it in the private sector or in the public sector is likely to exhaust the capacities of the local labour markets in terms of qualified staff in the foreseeable future. In some cases a lack of scientific staff for R&D is already reported. This is caused by brain drain and over-ageing (e.g. Estonia, Latvia, Lithuania). The intention of most NMSs to invest the foreseen EU structural funds into R&D infrastructure and innovation projects, will also create a pressure on the countries education system to provide the research staff that contribute in a sustainable way to the creation of knowledge. While this problem may be overcome in the medium to long term by reinforcing efforts to educate a new generation of engineers and scientists, it may lead to a scarcity of qualified personnel in those locations where already now substantial further investment in manufacturing and/or R&D is planned (e.g. in the automotive industry in the Slovak Republic). The least that can be concluded from this observation is that it is not very likely that the NMS will be able to provide a “labour reserve” of knowledge workers to compensate for foreseeable shortages in the EU-15 countries.

Labour costs have been a major advantage and reason for FDI in the New Member States, in production even more than in R&D. Some sectoral studies show that national economic policies are already faced with the diminishing competitive advantage by means of growing wages (e.g. in Estonia). Although this factor was not reported to be that important in the sectoral studies, this factor is frequently named as important.

As a third key factor, home markets, tend to play a particularly important role with respect to the local embedding of R&D. While some foreign R&D investment was motivated by the ease of access to the large internal European market, in some sectors the national markets are also an important argument for investment. This holds, for instance, in the pharmaceutical industry where specific conditions and relationships prevail with hospitals, universities and key scientists, thus offering opportunities that are favourable to the creation of niche markets, which, however, have been exploited only in rare cases. A different situation can be observed for IT services in Estonia, where the combination of qualified personnel and demand for an upgrading of service quality was conducive to the establishment of a strong national R&D market.

A sustainable embedding of R&D might not always be guaranteed in the case of FDI. Localised R&D could on the one hand lead to local value added. On the other hand, FDI might skim the cream of high-potential researchers in labs that produce “footloose” R&D for value added elsewhere in the world.

The access to a well-developed innovation infrastructure is of particular relevance when it comes to the question of how to ensure the embedding of foreign R&D investment in the national research and innovation systems. Through institutionalised co-operation arrangements with foreign investors and the building of networks, mutual learning processes and dependencies can be created that contribute to the upgrading of the research and innovation landscape of a country. Unfortunately, very few examples of this type of embedding and networking can be observed so far.

As compared to these three key factors, it is difficult to assess the role of favourable framework conditions (e.g. tax incentives). While they certainly matter for specific decisions, the interviews conducted in the course of the project tend to suggest that their importance seems to be over-estimated. If available, specific incentives are welcome, but the main determinants of foreign investment lie, as noted above, elsewhere.

In spite of the emphasis put on foreign private R&D investment, the domestic private R&D performers should not be overlooked. Most case studies concentrated on larger firms that are often part of MNCs. Hardly perceivable by statistical methods, here and there, there seem to start-up some R&D intensive enterprises in the biotech-sector (e.g. in Lithuania). However, hardly any sector specific information is available on the dynamics of R&D intensive start-ups in the NMSs.

From this analysis, a number of issues arise that cut across as critical for the future and thus requiring particular policy attention:

- The consideration of national and sectoral innovation systems to ensure the embedding of R&D;
- The future development of the human resource base as a pre-condition for performing R&D and thus for attracting R&D investment;
- The continuous improvement of the innovation infrastructure (universities, research centres, etc.), not only as sources of qualified R&D personnel, but also as potential partners for industrial R&D;
- A growing attention to the role of services, either as stand-alone research-intensive activities (e.g. KIBS) or as support services to R&D performed in other sectors (e.g. standardisation, IT services);
- Improving the innovation climate by structural measures rather than by financial incentives. This concerns, for instance, also the strengthening of the relationships between different innovation actors, private and public ones. There are already some examples of private firms getting engaged in funding of R&D centres or university institutes;
- Bundling of national R&D capacities (e.g. through national technology platforms) and seeking a better co-ordination with European initiatives.

## **2 Future Research Needs**

This study has been of an exploratory nature and was not meant to deeply investigate all aspects that would have been worth investigating. However, it was going into sufficient depth to identify a number of research needs for the future. These can be subsumed under five main headlines:

### **Data availability (to be based on analysis of availability matrix)**

Internationally comparable data are available on sectoral level for more countries than expected prior to the project. The EUROSTAT database provides good raw material for data analysis. It is however not always clear which data are available at which level and in which part of the EUROSTAT database. Additional efforts by EUROSTAT to further improve the usability of the database would be welcome for the kind of projects we conducted.

Another major issue is to facilitate deeper, more sophisticated analyses by making available data currently stored in different data sets: census, R&D and innovation surveys. Only these micro level data can provide a basis for sound, meaningful econometric analyses of the inter-relationships between R&D, innovation, other characteristics and firm and their ultimate performance. Of course, confidentiality of individual firm data should be maintained, but as the practice of various countries, e.g. that of Canada, shows it is possible. The European Commission – based on a detailed discussion with the national authorities, the EUROSTAT, businesses and legal experts – might consider developing a set of guidelines to facilitate these types of analyses, which seem to be useful for policy-makers (both at an EU and national

level), businesses as well as advancing academic research on innovation processes, ultimately underpinning more reliable policies and strategies.

### **Broadening and deepening the empirical base**

The sectoral and company case-studies conducted in the context of this project could not provide more than a first impression of the richness of the patterns, determinants and impacts of private R&D investment in the NMSs. For a more systematic investigation of the subject matter, both a broadening and a deepening of sectoral studies would be needed, in order to capture the high degree of specificity of national *and* sectoral characteristics. Three priorities can be mentioned in this respect:

- There were some apparent gaps in the selection of sectors investigated. This refers in particular to the service sector where only a few and very heterogeneous segments could be investigated.
- While some sectors like automotive and pharmaceutical were quite well covered in this study, it will be imperative to ensure better comparability of sectoral case-studies by focusing in a follow-up activity on just a few sectors.
- The number of company case-studies was by far too small to draw any generalised conclusions, given the considerable intra-sectoral differences, e.g. in terms of size, ownership, managerial capabilities, level of technological development/ sophistication, leading to significant gaps in performance and prospects.
- Empirical studies are needed to investigate in more detail the science-industry relationships and historical patterns of co-operation between research institutes and industry. Such studies would deliver information why in some countries and sectors the relationships are exploited while in others not, and, hence, would allow to develop specific research and innovation policy measures.

As regards the deepening of the investigation, in particular the impacts of private R&D investment will require further analysis.

### **Impacts of private sector R&D**

Little information is available on the impacts of private sector R&D, either at firm or sectoral level. Only very few studies could be identified that provide information on impacts, indicating a need for further research. In general, the role and impact of private sector R&D would have to be analysed in the context of company strategies, differentiating at least some basic types of companies (e.g. MNCs and domestic niche players) and their respective strategies.

As a first hypothesis with respect to basic types of company R&D strategies, the following four types could be suggested as a tentative indication from the case studies conducted:

- „A“ companies, these are *autonomous domestic players* that manage to initiate and implement their own R&D strategies and operate on domestic and/or international markets (e.g. financial intermediaries in Estonia, biotech niche players in Lithuania).
- „B“ companies, these are firms that are embedded in *global R&D networks* and are mostly subsidiaries of foreign companies in the case of NMSs (e.g. automotive, pharma).
- „C“ companies, these are firms that perform *adaptation-oriented R&D* in order to adapt existing products and services to local market needs and regulations (e.g. telecom equipment providers, IT services).
- „D“ companies, these are firms with *“invisible” R&D* which is embodied in services or a cross-cutting activity in a firm’s organisational units (e.g. service providers, SMEs).

In order to refine and substantiate this typology, additional research work would be required, based on detailed company case studies focusing on motivations for R&D, its embedding in wider firm strategies, the respective roles of intra- and extramural R&D and in general the local embeddedness of R&D activities as reflected in ties with the wider research infrastructure (universities, clusters, etc.) and spill-over effects. These kinds of data should provide an indication of the efficiency of different types of R&D investment for the upgrading of the innova-

tion system. Due to the lack of statistical data, such a case study based approach would be particularly interesting in small countries.

### **Impacts of policy measures**

Finally, from a policy perspective, there are five main issues that would require further investigation in order to better assess the role and the impact of different types of policy measures:

- The impact of targeted policy measures to attract and embed foreign R&D investment:  
Several New Member States have taken targeted measures (e.g. tax and investment incentives) to attract FDI. These are not targeted to increase private R&D investment. Although targeted measures have been quite successful in raising FDI, it is unclear whether these incentives are sufficient to ensure that this investment will stay and not move elsewhere once the conditions have changed. In other words, the key question concerns the sustainable embedding of private R&D investment in the innovation systems of the NMSs.
- The impact of targeted measures to leverage private R&D funding:  
Rather than addressing specifically foreign firms, efforts have also been made to strengthen domestic private investment in R&D and innovation, e.g. facilitating access to venture capital, supporting spin-offs, etc.
- The role of publicly funded innovation infrastructures for attracting and embedding private R&D investment:  
Another policy lever with respect to private R&D investment consists of the upgrading of the innovation infrastructure, i.e. the creation of – at least partly – publicly funded research and research-facilitating organisations (technology transfer centres, competence centres, etc.). In a wider sense, investment in the university system also falls under this category, thus adding the educational and human resource dimension.
- The role of national platforms and clusters:  
As a co-ordination measure, the building of sectoral or technology-specific platforms is about to be implemented in some NMSs (e.g. Poland). There are potential benefits to be reaped by these measures, for instance in terms of international visibility, economies of scale, and influence on European level agenda-setting, but there is still a need to develop models and approaches for how to implement these platforms.

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## V. Acronyms / Glossary

Acronym/ Term	Description
BERD	Business enterprise expenditure on R&D
bn.	billion
CMEA	Council of Mutual Economic Assistance
CSO	Hungarian central statistical office
GDP	Gross domestic product
FDI	Foreign direct investment
FTE	Full time equivalent - employment
KIBS	Knowledge intensive business services
NMSs	New Member States of the EU
mio.	million
MNC	Multi national company
MRP	European Mutual Recognition Procedure
R&D	Research and development
REACH	EU standard - Registration, Evaluation and Authorisation of Chemicals
T1, 2, 3	Tier one to three suppliers in the value chain of car manufacturing
USSR	Soviet Union
CY	Cyprus
CZ	Czech Republic
EE	Estonia
LV	Latvia
LT	Lithuania
HU	Hungary
MT	Malta
PL	Poland
SK	Slovakia
SI	Slovenia

## VI. Annexes

### **Availability Matrices for NMSs**

The following tables include all data sources and publishing organisations that were used to provide the availability matrixes for the new member states. For each data source a source number is given to identify the data sources in the availability matrices.

Cyprus	
Source number in the availability matrix	1,2
Data Source	1: Research and Development Statistics (2001, 2002, 2003), 2: Industrial statistics
Publishing organisation	Statistical Office of Cyprus, Ministry of Finances
Source number in the availability matrix	3
Data Source	National Accounts
Publishing organisation	Ministry of Finance, Dept. of Statistics
Source number in the availability matrix	4
Data Source	EUROSTAT Internet Database - <a href="http://epp.eurostat.cec.eu.int">epp.eurostat.cec.eu.int</a>
Publishing organisation	EUROSTAT

Czech Republic	
Source number in the availability matrix	1
Data Source	Research and Development Indicators for the CR 2004 - <a href="http://www.czso.cz">http://www.czso.cz</a> ( <a href="http://www.czso.cz/eng/edicniplan.nsf/p/9601-05">http://www.czso.cz/eng/edicniplan.nsf/p/9601-05</a> )
Publishing organisation	Czech Statistical Office
Source number in the availability matrix	2
Data Source	Research and Development Indicators in the CR 2003 - <a href="http://www.czso.cz">http://www.czso.cz</a> ( <a href="http://www.czso.cz/eng/edicniplan.nsf/p/9601-04">http://www.czso.cz/eng/edicniplan.nsf/p/9601-04</a> )
Publishing organisation	Czech Statistical Office
Source number in the availability matrix	3
Data Source	Research and Development Indicators in the CR 2002 - <a href="http://www.czso.cz">http://www.czso.cz</a> ( <a href="http://www.czso.cz/csu/edicniplan.nsf/p/9601-03">http://www.czso.cz/csu/edicniplan.nsf/p/9601-03</a> )
Publishing organisation	Czech Statistical Office
Source number in the availability matrix	4
Data Source	Research and Development Indicators in the CR 1995 - 2002 - <a href="http://www.czso.cz">http://www.czso.cz</a> ( <a href="http://www.czso.cz/csu/edicniplan.nsf/p/9610-04">http://www.czso.cz/csu/edicniplan.nsf/p/9610-04</a> )
Publishing organisation	Czech Statistical Office

Source number in the availability matrix	5
Data Source	Technical Innovation in the Czech Republic 2002-2003 (CIS 3) - <a href="http://www.czso.cz">http://www.czso.cz</a> ( <a href="http://www.czso.cz/eng/edicniplan.nsf/p/9605-04">http://www.czso.cz/eng/edicniplan.nsf/p/9605-04</a> )
Publishing organisation	Czech Statistical Office
Source number in the availability matrix	6
Data Source	Technical Innovation in the Czech Republic 1999-2001 (CIS) - <a href="http://www.czso.cz">http://www.czso.cz</a> ( <a href="http://www.czso.cz/eng/edicniplan.nsf/p/9605-03">http://www.czso.cz/eng/edicniplan.nsf/p/9605-03</a> )
Publishing organisation	Czech Statistical Office
Source number in the availability matrix	7
Data Source	EUROSTAT Internet Database - <a href="http://epp.eurostat.cec.eu.int">epp.eurostat.cec.eu.int</a>
Publishing organisation	EUROSTAT

Estonia	
Source number in the availability matrix	1
Data Source	R&D Yearbook 2003 (published in 2005) and on-line database <a href="http://www.stat.ee">www.stat.ee</a> (2006)
Publishing organisation	Statistical Office of Estonia
Source number in the availability matrix	2
Data Source	Community Innovation Survey (CIS 4)
Publishing organisation	Statistical Office of Estonia
Source number in the availability matrix	3
Data Source	EUROSTAT Internet Database - <a href="http://epp.eurostat.cec.eu.int">epp.eurostat.cec.eu.int</a>
Publishing organisation	EUROSTAT

Hungary	
Source number in the availability matrix	1
Data Source	Kutatás és fejlesztés/ Research and Development (annual bilingual publication)
Publishing organisation	Central Statistical Office
Source number in the availability matrix	2
Data Source	Innováció 1999-2001 / Innovation 1999-2001 (CIS 3 compatible)
Publishing organisation	Central Statistical Office
Source number in the availability matrix	3
Data Source	Innováció 2003 / Innovation 2003 (CIS light compatible)
Publishing organisation	Central Statistical Office
Source number in the availability matrix	4
Data Source	EUROSTAT Internet Database - <a href="http://epp.eurostat.cec.eu.int">epp.eurostat.cec.eu.int</a>
Publishing organisation	EUROSTAT

Latvia	
Source number in the availability matrix	1
Data Source	Research and Development Statistical Data Collection
Publishing organisation	Central Statistical Bureau of Latvia
Source number in the availability matrix	2
Data Source	EUROSTAT Internet Database - epp.eurostat.cec.eu.int
Publishing organisation	EUROSTAT

Lithuania	
Source number in the availability matrix	1
Data Source	Lithuanian Statistics on Science and Technology (Research activities), B27
Publishing organisation	Statistical Office of the Lithuanian Republic - www.std.lt, EUROSTAT Internet Database - epp.eurostat.cec.eu.int
Source number in the availability matrix	2
Data Source	Community innovation survey
Publishing organisation	Statistical Office of the Lithuanian Republic, www.std.lt, European Statistics on Science and Technology
Source number in the availability matrix	3
Data Source	EUROSTAT Internet Database - epp.eurostat.cec.eu.int
Publishing organisation	EUROSTAT

Malta	
Source number in the availability matrix	1
Data Source	Innovation Survey (Extended Community Innovation Survey)
Publishing organisation	National Statistics Office, Malta
Source number in the availability matrix	2
Data Source	EUROSTAT Internet Database - epp.eurostat.cec.eu.int
Publishing organisation	EUROSTAT

Poland	
Source number in the availability matrix	1
Data Source	Science and Technology Yearbook (Nauka i technika)
Publishing organisation	Central Statistical Office (Główny Urząd Statystyczny)
Source number in the availability matrix	2
Data Source	EUROSTAT Internet Database - epp.eurostat.cec.eu.int
Publishing organisation	EUROSTAT

Slovakia	
Source number in the availability matrix	1, 2

Data Source	1: The R&D Yearbook and 2: Selected Data on R&D Organisations in Slovakia No. 1 and 2 (Sources 1 and 2 largely overlap. Since 2005 Source 2 is cancelled and all information related to R&D will be published in Source 1)
Publishing organisation	Statistical Office of the Slovak Republic
Source number in the availability matrix	3
Data Source	(Community innovation survey)
Publishing organisation	Statistical Office of the Slovak Republic
Source number in the availability matrix	4
Data Source	EUROSTAT Internet Database - epp.eurostat.ec.eu.int
Publishing organisation	EUROSTAT

Slovenia	
Source number in the availability matrix	1
Data Source	Survey on Research and Development
Publishing organisation	Statistical Office of the Republic of Slovenia
Source number in the availability matrix	2
Data Source	Community Innovation Survey
Publishing organisation	Statistical Office of the Republic of Slovenia
Source number in the availability matrix	3
Data Source	EUROSTAT Internet Database - epp.eurostat.ec.eu.int
Publishing organisation	EUROSTAT

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**Abstract**

In general, evidence suggests that the current growth in the NMS seems to refer mainly to progressing structural changes, some emerging sectors, etc. and to an increasingly efficient allocation of production factors rather than to catching up in terms of R&D performance and getting closer to the technological frontier. But, although investment in R&D may currently appear to be only a minor source of economic growth in the NMS, with respect to the mid to long term perspectives of these countries the importance is supposed to be rising.

Given the distance of the NMS to the technological frontier and also the gap in terms of R&D intensity (Barcelona target) compared to the remainder of the EU, political emphasis might currently be more usefully on promoting easy access to, and absorption of, knowledge generated elsewhere accompanied with a sophisticated master plan for improving the existing R&D and innovation capacities systematically. In fact, making the NMS an attractive location for R&D appears to be a straightforward policy objective, but any corresponding measure should be embedded in an overall improvement of the institutional/environmental framework conditions in order to ensure sustainable investments in R&D in the NMS.

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