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by

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Diversity in Firms' Innovation Strategies and Activities

Main findings of interviews and implications in the context of the Hungarian national innovation system

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paper prepared for the Mycro-Dyn project

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1 INTRODUCTION

Hungary has all the major elements of a potentially successful national innovation system (NIS): a fully fledged education system; internationally recognised research units both at universities and the institutes of the Academy of Sciences; an increasing number of business R&D units, several of them operated by multinational firms and thus integrated into international networks; a number of government bodies engaged in science, technology and innovation (STI) policy-making and a considerable number of policy schemes in place; various types of professional associations and chambers; a functioning capital market, complete with venture capital funds; rules on intellectual property rights up to international standards; legislation compatible with the requirements of a market economy based on private property; apparently creative people; etc. Yet, innovation indicators suggest a poor performance in international comparison.

Two major reasons can be thought of when discussing this apparent contradiction. First, although these 'nodes' of the NIS are set up, a number of them do not work satisfactorily, or still fledgling. Second, as innovation studies stress, the major factor determining the overall innovation performance is not the performance of the individual organisations, but the intensity and quality of linkages and co-operation among them. (Fagerberg *et al.* (eds) [2005]; Lundvall *et al.* [2002]; Niosi [2002])

This paper cannot analyse in detail the major characteristics and operation of the principal players of the Hungarian NIS, and thus cannot tackle the first hypothetical explanation.[1] Rather, it is focussing on just one element of this broad picture: the innovation activities of Hungarian firms. Nevertheless, firms are supposed to be the engines of an innovation system in a market economy context, and hence this issue merits a close attention.

The Micro-Dyn project is applying various analytical approaches and tools when analysing firms' innovation activities from different angles (e.g. innovation strategies, market dynamics, competitiveness, regional and labour issues, internationalisation). This paper reports on the findings of interviews conducted with Hungarian firms, i.e. it mainly relies on qualitative analysis. At a later stage, an attempt might be made to find an overarching analytical framework under which these results can be juxtaposed with those stemming from quantitative methods – utilising a much larger sample –, especially when drawing broad theoretical conclusions and identifying policy implications.

In more details, interviews have been conducted on firms' overall business and innovation strategies and innovation activities to pursue three interconnected aims:

- better understand firm behaviour by analysing qualitative features of innovation processes (motivations, dynamics, linkages among driving factors and collaboration among actors);
- identify and sharpen hypotheses and research questions for quantitative analyses;
- derive policy implications.

The paper is organised as follows. To set the scene, a brief overview of the Hungarian NIS is offered in Section 2, and the major performance indicators are presented in international comparison in Section 3. Then the sample is described and the major interview findings are summarised in Section 4. The concluding section highlights implications for innovation surveys' methods, further quantitative analyses, as well as innovation policies and policy analyses.

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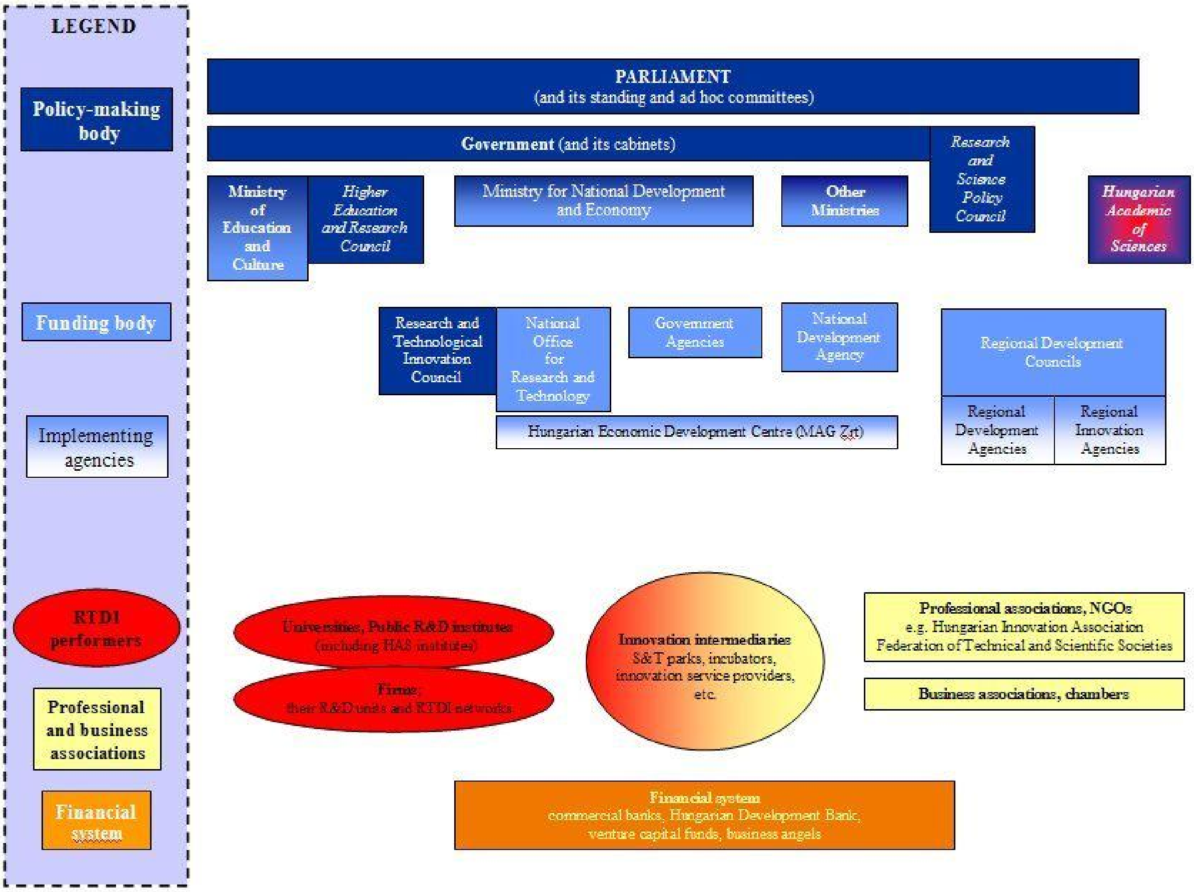
[1] For a recent, detailed discussion on the major players of the Hungarian NIS, see, e.g. Havas and Nyiri (eds) [2007] and OECD [2008].

2 THE HUNGARIAN NIS: AN OVERVIEW

Given the main research questions of the Micro-Dyn project, this paper is focussing on the R&D and innovation activities of firms, but it also describes the STI decision-making bodies, the organisations implementing STI policies, and provides a brief a characterisation of two other research performing sectors: universities and R&D institutes.[2] The weight of non-profit research organisations, just as in most OECD countries, is rather small in Hungary: their share in performing R&D activities, measured in utilising the gross expenditures on R&D (GERD), is below 1%. This sector, therefore, is not discussed below.

Figure 1 highlights the different players of the Hungarian NIS – although not all elements will be discussed in this paper.

Figure 1: The Hungarian NIS as of February 2010



Source: Compiled by the author

2.1 The STI policy governance system

The Education and Science Committee, together with the Economic and Informatics Committee of the Parliament are the highest-level political bodies in the field of STI policy. Recognising the cross-sectoral nature of STI policies, a sub-committee of the Education and

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[2] In the Hungarian statistical nomenclature the "government sector" – as it is defined by the OECD – is called „R&D institutes and other research units"; i.e. these two terms are equivalent. The second part of the Hungarian term, namely "other research units" refers to R&D units operated at/by national and regional archives, libraries, museums, hospitals and ministries. In brief, the following three notions should be understood as synonyms in this report: the government sector; R&D institutes and other research units; (publicly financed) R&D institutes.

Science Committee of the Parliament, called Science and Innovation Policy ad hoc Committee, was established in August 2007.

The *Science and Technology Policy Council* (TTPK) had been the highest-level government body – headed by the prime minister – charged with the task co-ordinate STI policy decisions for several years. It was abolished in March 2009, and then re-established in September 2009 by the new government – taking office in April 2009 – under a new name, *Research and Science Policy Council*, and with somewhat revised responsibilities. It held its first meeting on 17 February 2010, chaired by the prime minister.[3]

A new position of *Minister without portfolio* was created in May 2008 to co-ordinate and oversee STI policies, and to supervise the National Office of Research and Technology, the government agency responsible for implementing national technology and innovation policies, most notably the operation of the schemes financed by the *Research and Technological Innovation Fund*. In these matters, strategic decisions are taken by the *Research and Technological Innovation Council* (KuTIT). However, in April 2009 this position was abolished when a new government was formed, and the *Minister for National Development and Economy* took over the responsibilities of the Minister without portfolio.

The *Ministry of Education and Culture* (OKM) plays a key role in the formation and implementation of science and education policies. It supervises the state education system from elementary schools to universities, except the defence and police education institutes, thus it has full responsibility in providing human resources for the economy. The *Higher Education and Research Council* (FTT) is an advisory body, which assists the Minister in tasks and decisions related to higher education and academic research.

The *Hungarian Academy of Sciences* (MTA) is a legal entity, a public body having self-governing rights. In brief, its main tasks are to develop, promote and represent science. Although it could also be regarded as one of the most important research performers (through its network of research institutes, see below), its role in priority-setting in the field of science policy cannot be neglected, either. Most notably, the MTA has significantly influenced the government's mid-term STI policy strategy (2007-2013). Furthermore, the President of the MTA, through various bodies and mechanisms, plays an active role in STI policy-making.

The *Regional Development Councils* play a minor role in setting STI policies at a regional level.

The *National Office for Research and Technology* (NORT; or NKTH) is responsible for the government's technology and innovation policy, devises R&D and innovation support schemes, etc. These schemes are financed by the Research and Technological Innovation Fund. Funds allocated through the Operational Programmes of the New Hungary Development Plan (2007-13) are managed by the *National Development Agency* (NDA or NFÜ). Both the NKTH and NFÜ schemes are administered by an implementing or intermediary organisation, called the Hungarian Economy Development Centre (MAG Zrt.).

2.2 Research performers

This sub-section is introducing the major research performers, indicating their weight in the Hungarian research system. Innovation activities are discussed in Section3.

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[3] Most likely a new government will take office after the general elections due in April 2010. Given the organisational instability of the STI policy-making system observed in the last 20 years, it is uncertain if the Research and Science Policy Council would continue its operation.

2.2.1 Research organisations and research staff

The number of R&D organisations has nearly doubled since 1995, due to a significant expansion in the higher education (HE) sector, especially up to 2004, but more recently given the boost in the business sector: from 226 R&D units in 1995 to 1,471 units in 2008. The largest number of research units is still operated in the HE sector, in spite of the declining trend since 2005: 1,552 of the total 2,821 in 2008. (Table 1)

Table 1: The number of R&D units by research performing sector, 1995-2008

	1995	2000	2002	2003	2004	2005	2006	2007	2008
R&D institutes	107	121	143	168	175	201	208	219	195
Higher Education	1,109	1,421	1,613	1,628	1,697	1,566	1,552	1,496	1,471
Business enterprises	226	478	670	674	669	749	1,027	1,125	1,155
Total	**1,442**	**2,020**	**2,426**	**2,470**	**2,541**	**2,516**	**2,787**	**2,840**	**2,821**

Source: KSH, Research and Development

The business sector became the largest employer of researchers (full-time equivalent, FTE) in 2006, with a share of 35.6%, and then reaching 42.8% in 2008. It is followed by the higher education sector (HE) with 31.7% in 2008 (down from around 40% in 2000-2004) and the government sector with a weight of 25.5% (down from around 40% in the second half of the 1990s). (Tables 2-3)

Table 2: Employment of (FTE) researchers by research performing sector, 1995-2008

	1995	2000	2002	2003	2004	2005	2006	2007	2008
R&D institutes	3,905	4,653	4,622	4,741	4,693	4,959	5,226	4,572	4,720
Higher education	4,044	5,852	5,999	5,957	5,902	5,911	6,073	5,833	5,872
Business enterprises	2,550	3,901	4,344	4,482	4,309	5,008	6,248	6,986	7,912
Total	10,499	14,406	14,965	15,180	14,904	15,878	17,547	17,391	18,504

Source: KSH, Research and Development

Table 3: Share of (FTE) employment by research performing sector, 1995-2008 (%)

	1995	2000	2002	2003	2004	2005	2006	2007	2008
R&D institutes	37.2	32.3	30.9	31.2	31.5	31.2	29.8	26.3	25.5
Higher education	38.5	40.6	40.1	39.2	39.6	37.2	34.6	33.5	31.7
Business enterprises	24.3	27.1	29.0	29.5	28.9	31.6	35.6	40.2	42.8
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: author's calculations based on KSH data

2.2.2 R&D spending

The business sector used the largest amount of funds on R&D already in 1995, followed by the government sector and higher education, and this ranking has not changed since then. The gap between firms and the other two research performing sectors, however, has widened significantly since 2004. The business sector spent more on R&D in 2007-2008 than the two other sectors combined. (The sources of R&D spending are discussed in Section 3.

Table 4: Distribution of GERD by research performers, 1995-2008 (m HUF, at current prices)

	1995	2000	2002	2003	2004	2005	2006	2007	2008
R&D institutes	13,413	27,494	56,328	55,091	53,640	58,171	60,373	59,377	62,314
Higher education	10,201	25,310	43,135	46,972	44,615	52,246	57,943	57,365	58,704
Business enterprises	16,129	46,704	60,828	64,566	74,641	89,703	114,872	123,669	140,042

Source: KSH, Research and Development

3 HUNGARY'S R&D AND INNOVATION PERFORMANCE

Hungary's performance in R&D and innovation (RTDI) is presented in this section, covering the three major RTDI performing sectors, in comparative perspective. First a broad brush international comparison is offered, and then a more detailed analysis is provided, based on standard input and output indicators, that is, R&D expenditures and personnel, publications and citations, patenting, industrial design and trademarks, and innovation performance of businesses.

At a first glance, Hungarian RTDI activities lag considerably behind the OECD average by most indicators. First, the overall level of R&D activities is still way below the OECD average. Second, R&D activities of businesses are significantly lower than the OECD average. From a different angle, the government and higher education sectors account for a much higher share of R&D activities. (Table 5)

Table 5: Main comparable RTDI indicators of Hungary and the OECD, 1995-2007

		1995	2000	2002	2004	2005	2006	2007
Total								
GERD as a percentage of GDP	*Hungary*	0.71	0.8	1.00	0.88	0.94	1.00	0.97
	OECD	2.07	2.23	2.23	2.19	2.23	2.26	2.29
GERD per capita population (current PPP $)	*Hungary*	64.8	96.2	147.1	142.3	160.2	180.4	181.3
	OECD	403.4	534.5	573.6	615.1	657.2	705.7	747.6
Total researchers per thousand total employment	*Hungary*	2.9	3.5	3.6	3.9	3.8	4.1	4.5
	OECD	5.9	6.3	6.6	7.2	7.2	7.3	7.4
Business								
BERD as a percentage of GDP	*Hungary*	0.31	0.35	0.35	0.36	0.41	0.48	0.49
	OECD	1.37	1.56	1.51	1.48	1.51	1.56	1.59
Percentage of GERD financed by industry	*Hungary*	38.4	37.8	29.7	37.1	39.4	43.3	43.9
	OECD	59.5	64.4	62.4	62.1	62.1	62.8	63.8
Percentage of GERD performed by businesses	*Hungary*	43.4	44.3	35.5	41.1	43.2	48.3	50.3
	OECD	66.8	69.7	67.7	67.6	68.0	69.0	69.6
Percentage of BERD financed by industry	*Hungary*	78.3	75.8	69.3	77.4	77.8	75.6	74.9
	OECD	85.9	89.2	89.6	89.4	89.6	89.8	90.1
Researchers in business as a percentage of national total	*Hungary*	27.9	27.1	29.0	29.5	28.9	31.5	35.6
	OECD	61.9	63.7	64.3	65.1	64.3	64.3	64.9
Higher Education								
HERD as a percentage of GDP	*Hungary*	0.18	0.19	0.25	0.22	0.24	0.24	0.23
	OECD	0.33	0.38	0.39	0.39	0.39	0.39	0.38
Percentage of GERD performed by HEIs	*Hungary*	24.8	24.0	25.2	24.6	25.1	24.4	23.3
	OECD	16.2	17.0	17.4	17.7	17.6	17.1	16.8
Percentage of HERD financed by industry	*Hungary*	2.1	5.5	11.8	12.9	11.8	13.0	13.7
	OECD	6.2	6.2	6.2	6.1	6.2	6.3	..
Government								
GOVERD as a percentage of GDP	*Hungary*	0.18	0.21	0.33	0.26	0.26	0.25	0.23
	OECD	0.30	0.23	0.27	0.27	0.26	0.26	0.25
Percentage of GERD performed by the gov't sector	*Hungary*	25.6	26.1	32.9	29.6	28.0	25.4	24.2
	OECD	14.4	10.3	12.2	12.1	11.8	11.4	11.1
Government researchers as a percentage of national total	*Hungary*	33.6	32.3	30.9	31.2	31.5	31.2	29.8
	OECD	9.7	8.1	7.6	7.4	7.4	7.4	7.3

Source: OECD, Main Science and Technology Indicators

3.1 Volume and composition of GERD

Gross R&D expenditures (GERD) fluctuated between 0.7-0.8% of GDP until 2000, and between 0.9 and 1% since 2001. GERD, however, has grown significantly in absolute terms since 2004, and reached HUF 266.4 bn (~ EUR 1 bn).

Table 6: Gross R&D expenditures (GERD) in Hungary, 1998-2008 (current prices)

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
GERD (bn HUF)	71.2	78.2	105.4	140.6	171.5	175.8	181.5	207.8	238.0	245.7	266.4
GERD/GDP (%)	0.70	0.68	0.82	0.94	1.01	0.95	0.89	0.95	1.00	0.97	1.00
GERD per capita (USD)*	72.2	76.4	96.2	125.6	147.1	145.1	142.3	160.2	180.4	181.3	..

Source: KSH, Research and development, GERD per capita: OECD, Main Science and Technology Indicators
* Current prices, PPP

As for the financial sources of GERD, the central budget has clearly played a dominant role in the 1990s. The share of businesses stagnated at around 38% in the late 1990s, followed by a temporary setback in 2001-2003. A considerable improvement has occurred since 2004, and hence this share reached in 48.3% in 2008. This is still a relatively modest figure, as the OECD average is well above 60% (64.5% in 2008).

Table 7: Gross R&D expenditures (GERD) by financing sources, 1998-2008 (%)

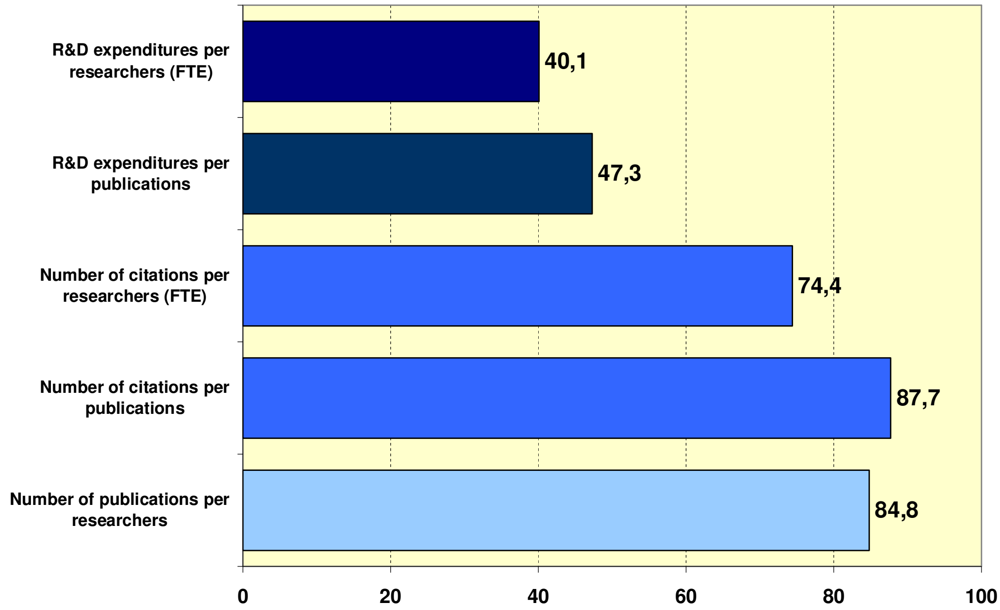
	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Business enterprises	37,7	38,5	37,8	34,8	29,7	30,7	37,1	39,4	43,3	43,9	48,3
Government	49,6	53,2	49,5	53,6	58,5	58	51,8	49,4	44,8	44,4	41,8
Other national source	2,8	2,7	2,1	2,4	1,4	0,6	0,7	0,5	0,6	0,6	0,6
Funds from abroad	4,8	5,6	10,6	9,2	10,4	10,7	10,4	10,7	11,3	11,1	9,3

Source: KSH, Research and development

3.2 Publications

The performance of Hungarian researchers compares favourably with the EU average, following a cost/benefit approach. The output per researcher is close to the EU15 average (85%), while funding is much lower: 40% of EU15 R&D spending per researcher and 47% funding per publications. The quality of publications – as suggested by the citation-related indicators – is also much closer to the EU average than the level of funding. (Figure 2)

Figure 2: Hungarian scientific performance by selected indicators, 2004* (EU15=100)**



Source: Eurostat for GERD and research personnel (FTE); Web of Science (Thomson Scientific) for publications and citations
* Citation period: 2004-2006
** Figure 2 follows the methodology and approach of Tolnai [2006]

A recent study, relying on the Web of Science database, has analysed the performance of Hungarian researchers by scientific fields, using three indicators: the number of publications (output) in 2001-2005, the impact factors of journals for publications (publication strategy) and the citation rate (impact of publications). (Schubert [2007]) As this issue is beyond the scope of the Micro-Dyn project, results are not summarised here.

3.3 R&D and innovation activities in the business sector

The structure of the Hungarian economy has changed significantly since 1990. The number of firms increased sharply, especially that of the micro-enterprises. The density of companies is higher than the EU average, while their average size is smaller.[4]

One of the most worrisome performance indicators of the Hungarian NIS is the low level of business expenditures on R&D in international comparison, measured either as a percentage of GDP or that of GERD. The Hungarian BERD/GDP ratio was a mere 44% of the EU27 average (0.49% vs 1.12%) in 2007, and 31% of the OECD average (1.59%). (OECD MSTI 2009/1)

Business R&D expenditures have significantly increased since 1995, albeit from a low level, and an especially fast growth has occurred from 2004 on. (Table 8) Although BERD has doubled between 1995 and 2005 (in constant prices), the BERD/GDP ratio only grew by some 32%, given the dynamic economic growth recorded until the mid-2000s.

[4] In 2003 the number of enterprises per 1000 inhabitants was 61 in Hungary and 49 in the EU15, the average size of firms was 5 employees in Hungary, while 7 in the EU15. (KSH, 2006b)

Table 8: Business R&D expenditures (BERD) in Hungary, 1995-2007

	1995	2000	2002	2003	2004	2005	2006	2007
BERD (m USD*)	319.3	435	484	483.1	535.2	629.1	775.7	789.8
BERD as percentage of GDP (%)	0.31	0.35	0.34	0.34	0.36	0.41	0.48	0.49
BERD as percentage of GERD (%)	43.4	44.3	35.5	36.7	41.1	43.2	48.3	50.3

Source: OECD, Main Science and Technology Indicators

* constant prices (USD 2000), PPP

The R&D activities of Hungarian firms are financed by three main sources. The most significant one is their own funds: 79.8% in 2008, that is slightly below the EU27 average of 82.7% (2006). Funds from abroad accounted for 11.4% of the Hungarian BERD,[5] well above the EU average (10.0% in 2006). Finally, the weight of public funds was 8.6% in 2008,[6] that is, just above of the EU27 average (7.2% in 2006). (KSH, Research and Development; OECD MSTI 2009/1)

As for the share of (FTE) researchers employed by businesses, Hungary lags considerably behind the EU27 and the OECD averages: 42.8% in 2008 (EU27: 49.0% in 2007; OECD: 64.9% in 2006). As already mentioned, the number of R&D units operated by enterprises has grown significantly – albeit from a very low figure. (Table 1) Hence, the average size of these units (measured by the number of FTE researchers per unit) has dropped to 8.2 in 2000, and then to 6.9 in 2008. This value is above the national average (5.1 in 2008), but way below the figure for publicly financed R&D institutes, namely 24.2.

The R&D expenditures of businesses are heavily skewed: large enterprises (i.e. those with at least 250 employees) accounted for the two-thirds of BERD in 2008, but their weight had been even higher, that is, 70 to 80 percent in 2000-2007. (Table 9)

Table 9: Composition of BERD by size of firms, 2000-2008 (%)

	2000	2001	2002	2003	2004	2005	2006	2007	2008
Micro-enterprises (0-9 employees)	3.0	3.1	5.3	5.2	3.3	3.7	5.1	7.1	8.5
Small enterprises (10-49)	5.4	4.9	6.9	6.7	6.9	7.1	9.7	10.8	11.8
Medium-sized enterprises (50-249)	21.3	22.4	12.2	9.6	7.9	8.6	12.3	10.8	12.8
Large enterprises (250-)	70.3	69.6	75.6	78.5	81.9	80.4	72.4	70.9	66.2
Unknown	-	-	-	-	-	0.2	0.5	0.4	0.7
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Source: KSH, Research and Development

With regard to the number of enterprises undertaking R&D activities, and the research personnel employed, the picture is more balanced, with micro and small enterprises having gained a larger share in recent years. (Tables 10-11)

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[5] This ratio had been much higher in previous years: 22.4% at its peak in 2003, and still between 15-18% in 2004-2007. Indeed, in international comparison that was an extremely high weight of foreign funds in financing BERD.

[6] Tax holidays for R&D, in line with international practice, are not included in this figure.

Table 10: The number of firms conducting R&D activities by size-categories, 2000-2008

	2000	2001	2002	2003	2004	2005	2006	2007	2008
Micro-enterprises (0-9 employees)	161	281	301	280	274	308	443	479	488
Small enterprises (10-49)	95	101	120	138	138	155	224	259	260
Medium-sized enterprises (50-249)	101	115	121	124	130	137	181	201	209
Large enterprises (250-)	121	133	128	132	127	131	143	147	146
Unknown	-	-	-	-	-	18	36	39	52
Total	**478**	**630**	**670**	**674**	**669**	**749**	**1,027**	**1,125**	**1,155**

Source: KSH, Research and Development

Table 11: Distribution of business R&D activities by size of firms, 2000 and 2008 (%)

	2000				2008			
	Number of research units	R&D personnel (FTE)	*Of which:* researchers	R&D expend.	Number of research units	R&D personnel FTE	*Of which:* researchers	R&D expend.
Micro enterprises (0-9)	33.7	7.1	8.1	3.1	42.3	13.7	14.1	8.5
Small enterprises (10-49)	19.9	10.0	9.5	5.4	22.5	19.2	17.0	11.8
Medium-sized enterprises (50-249)	21.1	27.7	28.0	21.2	18.1	20.7	21.3	12.8
Large enterprises (250-)	25.3	55.2	54.4	70.3	12.6	45.4	46.5	66.2
Unknown	-	-	-	-	4.5	1.0	1.1	0.7
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Source: KSH, Research and Development

Innovation survey data also suggest that SMEs play a minor – and diminishing – role: the share of innovative firms among the large ones was 44.4% in 1999-2001, while this ratio was 20.9% for small ones (with 10-49 employees). By 2004-2006, the former share has increased to 55.2%, and the latter dropped to 13.9%.

Table 12: The share of innovative enterprises in Hungary broken down by economic sector and size-categories, 1999-2001, 2002-2004 and 2004-2006 (%)

	1999-2001	2002-2004	2004-2006
Small enterprises (10-49 employees)	20.9	16.9	13.9
Medium-sized enterprises (50-249)	28.0	30.5	29.6
Large enterprises (250-)	44.4	52.4	55.2
Total	**23.3**	**20.9**	**17.7**

Source: Eurostat, CIS data

As large firms tend to be foreign-owned, businesses with majority or full foreign ownership spend disproportionately more on R&D than indigenous ones. Though the share of business R&D units operated at foreign-owned businesses has remained below 15%, these firms accounted for 66-74% of BERD in 2003-2007, decreasing to 59.2% in 2008.

Table 13: The number of business R&D units by ownership, 2003-2008

	2003	2004	2005	2006	2007	2008
Majority domestic	496	452	496	679	797	799
Majority foreign	45	47	44	59	62	57
Foreign (100%)	45	56	62	77	84	92
Majority state-owned	31	29	34	38	34	30
Majority local government-owned	10	9	8	12	11	10
Unknown, cannot be established	47	76	105	108	137	167
Total	**674**	**669**	**749**	**1,027**	**1,125**	**1,155**
Share of foreign-affiliated business R&D units	13.4%	15.4%	14.2%	13.2%	13.0%	12.9%

Source: KSH, Research and Development

Table 14: Distribution of BERD by ownership, 2003-2008 (bn HUF, at current price)

	2003	2004	2005	2006	2007	2008
Majority domestic	12.4	15.1	19.1	28.1	34.2	42.7
Majority foreign	15.9	27.1	32.7	44.7	34.5	38.0
Foreign (100%)	27.0	28.0	32.9	35.3	47.9	45.0
Majority state-owned	2.6	3.7	3.7	4.1	4.0	4.6
Majority local government-owned	0.3	0.2	0.3	0.3	0.3	0.2
Unknown, cannot be established	6.4	0.5	1.0	1.6	2.8	9.5
Total	**64.6**	**74.6**	**89.7**	**114.9**	**123.7**	**140.0**
Share of foreign-affiliated business R&D units	66.4%	73.9%	73.1%	69.7%	66.6%	59.2%

Source: KSH, Research and Development

Again, innovation data are in line with R&D figures: CIS3 results show that indigenous firms innovate to a much smaller extent (15.1%) than foreign (21.5%), and especially jointly owned ones (34.2%). The distribution of innovative firms by ownership is not available for either 2002-2004 or 2004-2006, but there is no reason to assume that this pattern has changed to a significant extent since 2001, that is, the year for which CIS3 data are available.

Business R&D expenditures as well as innovation activities are concentrated to large, foreign owned companies in a limited number of sectors. The chemical industry (mainly related to pharmaceuticals) accounted for 60.4% of the total R&D spending by manufacturing companies in 2006, and still 49.6% in 2008. (KSH) In other words, 5-6 large companies account for 35-40% of total Hungarian BERD. Several sectors perform way above the national average in terms of the share of innovative firms: chemicals, due to pharmaceuticals firms (51.9% in 2002-2004; 47.5% in 2004-2006), financial service providers (47%, and 39.5%, respectively), automotive (37.2%, and 37.3%), as well as electrical machinery and instruments (33.8% in 2002-2004). A significantly higher share of large firms is innovative in these sectors, too, than that of the small and medium-sized ones.

The above figures suggest that Hungary continues to suffer from a dual economy syndrome: it is composed of highly productive and technology-intensive firms (most of which are large and foreign-owned), and fragile, financially and technologically weak indigenous SMEs.

3.4 Patenting, industrial design and trademarks

Hungarian firms are far less active in filing applications for patents, industrial design and trademarks than their counterparts in advanced and EU27 countries. Indeed, Hungary shows the weakest relative performance in terms of intellectual property indicators in the European Innovation Scoreboard: a mere 5-20% of the EU average. The number of national patent applications has even decreased significantly since 2003. (Table 15) This sudden drop is due to the fact that Hungary joined the European Patent Convention on 1 January 2003, and thus foreign inventors have filed their applications with the European Patent Office. The number of domestic patent applications has been stagnating at around 700-800 in recent years. This low patenting intensity reflects the level of indigenous RTDI activities, and also suggests a low level of IPR awareness.

Table 15: Patenting activities in Hungary, 2001-2008

	2001	2002	2003	2004	2005	2006	2007	2008
National patent applications	5,451	5,906	4,810	2,657	1,275	924	791	772
Number of granted patents	1,306	1,555	1,379	977	1,243	1,916	2,216	2,212
Valid patents	10,927	10,784	10,385	9,525	9,224	9,338	10,306	11,462
Of which validated national patents	10,927	10,784	10,385	9,513	9,125	8,408	..	..
European patents validated in Hungary	-	-	-	12	99	930	..	..

Source: MSzH data

However, at least two arguments should be recalled here as to why one should interpret these figures with a pinch of salt. First, when assessing the performance of NIS in general, one should bear in mind that a wide array of other means can be – and indeed, are – utilised by firms to protect intellectual property, many of which are not captured by measurable or readily available indicators. Moreover, propensity to patenting is highly varied across sectors, and hence the sectoral distribution of a national economy might heavily influence the intensity of patenting activities. Thus, a low level of patenting activities does not necessarily indicate a poor innovation performance.[7] Second, concerning specifically a catching up economy and its NIS, at that stage of development it might not be a meaningful (or feasible) target at all to produce as many patentable R&D results as possible. It seems to be more relevant to concentrate on (a) fostering the diffusion of new technologies and other forms of innovation; and (b) enhancing the learning capabilities for more efficient absorption of new methods and technologies.

3.5 Academia-industry co-operation in Hungary

There could be a variety of linkages in successful national innovation system among its players (businesses, academia, intermediary and service providers, policy-makers at various levels). Firms are involved in different ways – formally and informally – and to a varying

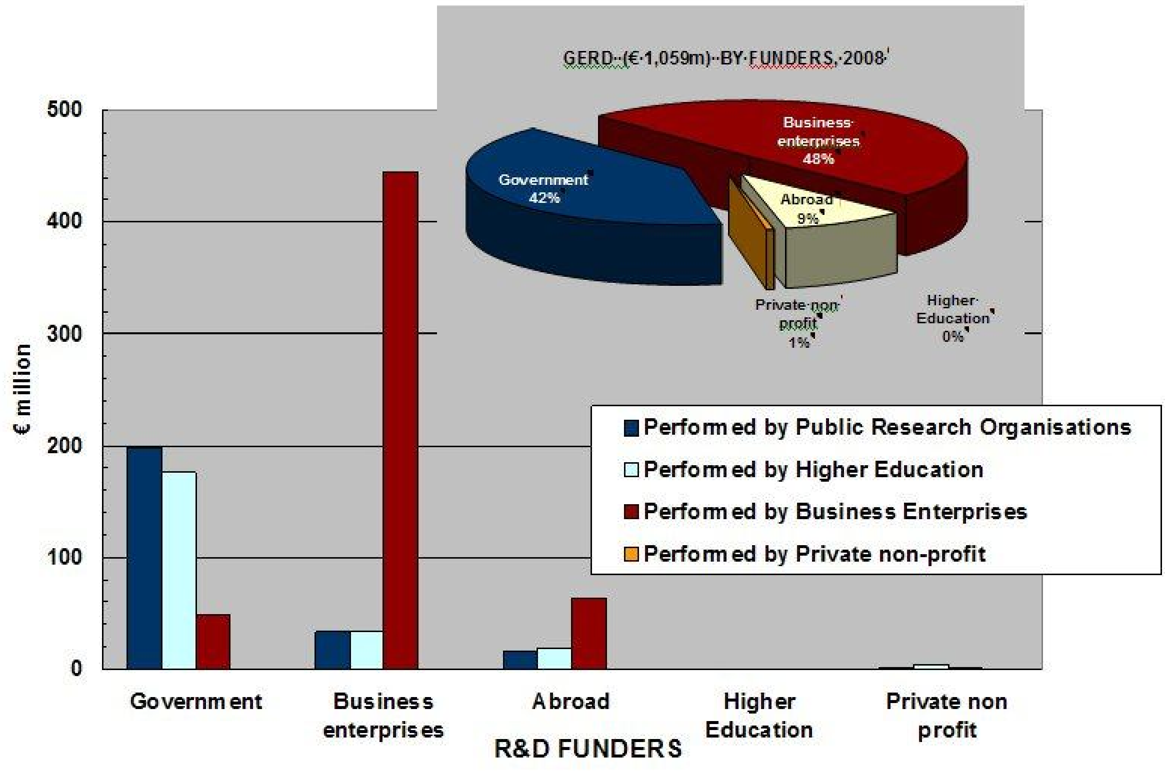
[7] This, of course, is not to suggest that the Hungarian NIS performs fabulously, in spite of the picture shown in the mirror of patenting activities.

degree in devising STI policy strategies and actual policy measures. The links between businesses and intermediary organisations (including players offering funds for innovation activities) is also a crucial factor in determining the performance of a given NIS, just as external linkages, that is, the internationalisation of RTDI processes[8] and STI policy formation. Of these linkages, only academia-industry co-operation is discussed in this paper.

A wide variety of knowledge and skills are required for innovation processes to be successful, and these different types of inputs are distributed among various actors. Thus, their co-operation is vital. CIS data, however, reveal a low intensity of innovation co-operation in Hungary. Several STI policy measures have been devised to tackle directly this challenge. Further measures, facilitating international co-operation are also of relevance, and co-operation is promoted by a number of other schemes, too, as a complementary objective.

Several striking features can be identified by analysing R&D funding flows.[9] The first one is the high share of funds from abroad, the bulk of which goes to business enterprises.[10] Second, business enterprises fund research activities both at HE institutes and in the government sector (R&D institutes) to a noteworthy extent. (Figure 3)

Figure 3: Funding flows



Source: Author's compilation based on Eurostat data

[8] Several foreign firms have integrated their Hungarian partners into international production and innovation networks by diffusing their technological and organisational innovations, as well as by setting high standards in terms of performance and quality of products. Hence, certain 'archipelagos' of the Hungarian NIS are created/ strengthened this way.
[9] Similar types of data on funding innovation activities are not readily available.
[10] It should be stressed here that financial support provided by the EU Structural Funds is accounted for as part of the state budget, i.e. it becomes "national" funding in statistics.

A closer look at the sources of Hungarian R&D expenditures indicates improving co-operation among the research actors. While only 4-5% of the total higher education expenditures on R&D (HERD) had been financed by firms in 2000-2001, this ratio jumped to 11-15% in 2002-2008 (14.7% in 2008). This is much higher than the EU27 or the OECD average (6.3% in 2008; and 6.3% in 2006, respectively). The only OECD member country with a higher share is Turkey. This high ratio of business funding might be attributed to the low level of the Hungarian HERD in absolute terms (€177-233m a year in 2002-2008, current prices): a few projects commissioned by firms, amounting to relatively small funds by international standards, can lead to a high weight of business funding in HERD.

The financial links between firms and publicly financed R&D institutes show a more varied picture in recent years: the share of firms in Government Intramural Expenditure on R&D (GOVERD) was 11-13% in 2000-2001, dropped by around 50% in 2002-2004, and then exceeded 10% again in 2005. Since 2006 this indicator has been in the range of 12.3-14.3%. These variations hint to a more general hypothesis: incentives provided by various policy tools are just one element of a bigger, more complex system influencing innovation behaviour of the major actors.

The share of GOVERD financed by industry is higher in Hungary than either the OECD or the EU27 average (3.8% [2006]; and 8.7% [2008], respectively). Yet, it was below the NZ, Polish, Finnish, and Slovak data (in descending order) in 2007. Still, it is a good position in international comparison. The low volume of the Hungarian GOVERD (€213-248m a year in 2002-2008, current prices), most likely, is an important factor in explaining this ranking.

Community Innovation Survey data indicate that industry-academia co-operation is not particularly strong in Hungary. The frequency of innovative firms' co-operation with higher education organisations first declined significantly (from 21.6% in 1999-2001 to 14.6% in 2002-2004), and then improved (17.5% in 2004-2006), but still below the 1999-2001 level. As for their co-operation with public labs, it is even less frequent. (Table 16)

Table 16: Share of innovative enterprises indicating co-operation with specified partners (percentage of all innovative enterprises)

	1999-2001	2002-2004	2004-2006
Other enterprises within the enterprise group	5.1	9.6	7.5
Suppliers of equipment, materials, components, or software	26.8	26.6	25.0
Clients or customers	24.8	20.0	16.0
Competitors or other enterprises in sector	10.9	14.2	12.6
Consultants*	14.6	13.9	15.2
Private R&D organisations	13.7		
Higher education organisations	21.6	14.6	17.5
Government or public research institutes	8.6	6.4	6.5

Source: KSH
* Co-operation with consultants and private R&D organisations has been merged since the 2002-2004 survey

4 Qualitative analysis of innovation activities: Interview findings

4.1 Rationale and motivation to conduct qualitative analysis

Qualitative analysis has been suggested to pursue the guiding principles of Micro-Dyn’s WP1 to complement quantitative analysis. Just to recall, innovation is a crucial part of competitiveness and job creation. Given that firms are the major actors in innovation processes, understanding how they innovate is important both for theoretical and policy analyses. As emphasised in the literature, strategies that firms rely upon to create, absorb and exploit knowledge in order to successfully innovate differ a lot across firms, sectors and countries, and getting a better understanding of this pattern as well as its causal underpinnings is central to the research agenda of Micro-Dyn. However, one of the main findings of innovation studies is that firms do not innovate in a vacuum but in close interaction with other players such as customers, suppliers, R&D institutes, etc. From a different angle, various types of knowledge, stemming from diverse sources, are sought by firms to underpin their innovation strategies. It also highlights the important point that innovation strategies cannot be analysed independently of the broader context that conditions the formation and results of such strategic action.

Until recently, the analysis of the above issues has been hampered by two major factors: i) lack of readily available firm level data; ii) lack of sufficiently large number of comparable case studies. As for the first obstacle, with the gradually increasing scope and coverage of the Community Innovation Survey (CIS), several relevant variables can be analysed by processing CIS data. Mcro-Dyn is exploiting this rich database for various WPs.

However, it is still important to combine those results with information from other sources, at the firm, sector and country levels, to arrive at a broader, more comprehensive picture. Thus qualitative analyses are needed to complement Micr-Dyn's – already pioneering – quantitative analyses to overcome the second obstacle mentioned above. To that end, it is crucial to conduct a sufficient number of interviews and case studies to reflect the diversity of firms, as well as the impacts of various factors affecting firms' strategies. It is also of paramount importance to align qualitative and quantitative analyses, i.e. to have an appropriate research design.

The qualitative analyses being performed for the Micro-Dyn project have rested upon the following postulations:

A) The characteristics of national, regional, and sectoral innovation systems play a decisive role in the success of innovation processes, and these qualitative elements thus play a role in determining firms' strategies and their success.

B) Depending on a given firm (its actual strategy, size, sector, ownership, etc.), the "weight" of the national/ regional/ sectoral innovation system might be rather different.

C) Besides the players mentioned above, STI policies (various schemes to promote R&D and innovation, e.g. taxation, grants, information and partnering/ networking services, etc.), regulation on IPR and other relevant issues; education, regional development, competition, investment promotion, trade and other polices; access to capital, the education system, professional associations, chambers are also important elements of an innovation system.

D) The most important feature of a given innovation system, however, is the way in which the respective players communicate, co-operate and compete.

The impact of these factors on firms' strategies and their implementation cannot be analysed by CIS data alone. Different types of qualitative analyses (literature surveys on innovation systems in the countries to be analysed; interviews with key players, case studies on different types of firms) are needed to complement the quantitative analyses performed in the framework of the Micro-Dyn project.

4.2 Methodology and the sample

Desk research has been conducted to identify sectors and types of companies which are particularly interesting to analyse the factors determining innovation capabilities and competitiveness. Building on these results, postulations listed above have been revisited, interview guidelines have been devised for interviews with firms.

The interview guidelines have addressed three blocks of issues:

- Background data on the firm
- Innovation strategy
  - links with overall business strategy of the firm
  - decision-making competences at the interviewed firm
  - internal division of labour
  - main co-operation partners in RTDI activities
  - role and impacts of domestic and EU STI policies
- Successful and abandoned innovations

A fact sheet had been sent – having conducted the interview – to collect background data on the given firm.

Seventeen interviews have been conducted at 14 firms and with policy-makers until February 2010, and a further 5-8 interviews are planned until June 2010. Companies have been selected to reflect diversity in terms of size, ownership, and R&D and innovation patterns of sectors (e.g. innovation activities of firms relying mainly on intra-mural or extra-mural R&D activities; extra-mural but "intra-sectorial" R&D activities; "extra-sectorial" R&D activities and non-R&D types of knowledge).

The firms interviewed so far are mainly foreign-owned, large enterprises, except 3 domestic owned SMEs. Six of the foreign-owned firms have been established as greenfield sites, another one was formally a takeover of an existing firm, but in practice it can also be classified as a greenfield investment, while the remaining four foreign owned enterprises had taken over Hungarian firms.

Reflecting the characteristics of the Hungarian innovation system and the relevance of sectors in terms of employment, contribution to GDP and exports, the following sectors are represented in the sample:

- pharmaceuticals: 4 firms
- automotive: 6 firms (one is a diversified one, active in other product markets, too)
- information and communication technologies (ICT) and electronics: 4 firms.

A more detailed statistical description of the sample will be prepared once all interviews are conducted. It should be stressed, however, that this work is not meant to be based on a statistically representative sample.

4. 3 Main findings stemming from the interviews

This version of the report highlights some key findings of the interviews. A more systematic analysis will follow when the remaining interviews are conducted.

4.3.1 Diversity of innovation strategies and activities

In line with the statistical evidence presented in Section 3, the interviews confirmed that *size, ownership and sector matter*. In general, *small, domestic firms* do not have the necessary skills and the required resources to devise innovation strategies, and face business and technological uncertainties in a conscious way. Yet, they are also engaged in innovation activities to improve their performance in order to stay in business or to cease new market opportunities. They are seldom involved in formal(ised) R&D activities or radical innovations; rather they implement incremental innovations to meet new technical specifications. Often these modified products are designed by the buyers – in case of a sophisticated value chain it might be another player in the chain, not necessarily the 'direct' buyer – and the Hungarian supplier adjust its machinery and production processes to be able to manufacture the new product in question. These modifications might not even be regarded innovations by the interviewees because these are not based on advanced R&D activities, leading to radically new technological solutions.

Size can 'overrule' behavioural patterns determined by ownership: a small firm with 20-30 employees, taken over by a geographically distant parent firm is likely to conduct similar type of RTDI activities as an indigenous one.

> A small firm in the sample had been faced by a new demand from a customer to clean more thoroughly the processed parts following the usual oil treatment. It was not possible by the available machinery, therefore either a new technology (i.e. high-pressure washing technologies), or new detergents were needed to comply with the customer's requirements. Following a thorough survey of potential solutions available on the market (e.g. offers from large chemicals firms), none of them proved financially feasible. The only viable solution was to modify the existing machinery by applying ideas developed in-house – but also approved by the customer. A typical domestic-owned firm would have behaved in the same way. In this case, however, even this technologically minor, and relatively inexpensive adjustment required the approval of the parent firm for quality assurance.

These process innovations might require organisational and/or managerial innovations, too, especially in the case of medium-sized firms, where procedures need to be more formalised and the organisational set-up more structured (less flexible) than in the case of small firms with 10-20 employees.

> A medium-sized firm in the sample – actually, in 2008, when the devastating impacts of the global crisis was felt only for a few months, it was on the brink to become a large firm – has recently introduced a management information software package (SAP), but some middle managers still prefer using sheets of papers for calculations and keeping records. Thus training is still needed to foster cultural changes. Organisational changes are also being prepared to clearly delineate decision-making competences and responsibilities. A consultancy service is providing professional assistance in bringing about these changes.

Hungarian *subsidiaries of foreign firms* tend to be at least *medium-sized*, but more often *large* enterprises. They usually organise their RTDI activities in the frame set by the overall business and innovation strategies of the parent firm, which, in turn, are defined by the sectoral patterns to a large extent. These are presented in this sub-section, while a tentative taxonomy of the role of RTDI activities (conducted in Hungary) in the overall business strategy of foreign-owned firms is discussed in the following one.

The intensity and sources of innovation activities differs markedly across sectors. The major features of three sectoral innovation and production systems are described below. In this respect, interviews have not uncovered striking differences between the findings of widely accepted sectoral studies and the behaviour of the interviewed firms, but some interesting new elements have been found. It is not possible to establish if these additional insights are due to some unique Hungarian features or simply had been overlooked by previous sectoral studies, which cannot go as deep as firm-level interviews.

Automotive industry

Japanese automotive firms, notably Toyota, had developed a brand new production paradigm, called lean production or Toyota system, and have taken the lead in several aspects by the

1970s. One of the most important innovations of lean production is the novel way to arrange and manage the assembler-supplier relationships. Unlike in Fordist mass production, lean production is based on trust and the realisation of the importance of co-operative efforts. A wide range of information, therefore, is regularly exchanged among assemblers and suppliers so as to improve efficiency by joint efforts. Different forms of financial, managerial and technological assistance are also provided by the assembler. Borrowing analogies from game theory, suppliers and assemblers are engaged in a zero-sum game in Fordist mass production, while in lean production both of them are interested in, and working for, enlarging the `cake', i.e. increasing profits to be distributed among them.

Another distinctive feature of the lean supply chain is its pyramid-like structure. In its original Japanese version, first-tier (T1) suppliers are tied to an assembler through ownership, usually with a minority stake, interlocking cross share-holdings and personnel links. Their tasks include not only manufacturing of certain parts and components but product design as well, either together with their assemblers or on their own.[11] As for manufacturing of a given part, though, not just a single supplier can be chosen, and hence competition for orders could be maintained.[12] Supply quota and target price, based on thorough, jointly conducted cost calculations and full exchange of all the relevant production and market information, are set in advance in multi-year contracts. Constant cost-cutting is not only anticipated, given learning effects, but deliberately planned; moreover, even fixed in the supply contract. Extra savings, stemming from further improvements achieved by suppliers, however, can be retained as profits, and thus incentives for additional cost-reducing innovations are built in into the system.

First-tier suppliers have also built their network, usually consisting of 20-60 firms. These second-tier (T2) suppliers, in turn, rely on thousands of small and medium-sized enterprises, producing basically simple, and labour-intensive products given their wage advantages compared to larger firms. Suppliers' performance is regularly evaluated using multiple criteria such as quality, design, delivery and price. Supply quotas, and thus profits, are awarded among suppliers according to the result of these evaluations.

As for the links among the players, there are two major features of this pyramid structure. An actor at the upper level offers technical and managerial assistance to introduce various types of innovations, and also conducts thoroughly audits on every single important aspects of the overall production process: purchasing inputs and equipment, logistics inside and outside a given plant, technologies and processes, quality assurance, management, marketing and finance methods.

The lean supply system displays a number of strategic strengths over mass production. First, it combines the co-ordination benefits usually associated with vertical integration with cost and efficiency discipline of markets. Second, and presumably more importantly, it facilitates both generation and fast diffusion of product, process and organisational innovations since there are no built-in conflicts between car producers and suppliers. It is hardly possible to exaggerate the importance of this advantage as the very nature of competition has undergone a major change: the former inter-firm competition has become a competition among networks of car producers and their suppliers. (Bongardt [1992])

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[11] 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 T1 supplier.

[12] Different authors provide diverse, somewhat contradictory accounts on the distribution of orders. Some of them emphasise single-sourcing, while others stress the importance of competition among suppliers. Compare, e.g. Bongardt [1992], Lamming [1993], Richardson [1993], Way, Schulte [1993] and Womack *et al.* [1991].

Former Fordist mass producers have also changed their way of operation: introduced just-in-time and total quality management, as well as 're-designed' their product design process. They also give longer term contracts to fewer direct suppliers, exchange production and sales information with the most important ones in a joint effort to reduce costs, and hence increase efficiency, and involve them into R&D projects, too.

It is practically impossible to delineate the boundaries of automotive industry and give an indication of its economic significance using readily available statistics. As a very wide range of products are used to assemble a motor vehicle – practically all industrial sectors supply the automotive industry –, data collected by statistical offices 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. The EU statistical classification also follows this line, i.e. *motor vehicle parts and accessories* (the "old" NACE 34.30[13]) excludes engine and tyre manufacturers, most of the electrical and electronic components, as well glass, plastic or certain castings and other metal parts. The Hungarian statistical system follows this practice, and thus figures only cover companies classified statistically as automotive firms. Relying on these types of data, 'narrowly defined' automotive industry (proxied as vehicle manufacturing, DM) has a significant weight in Hungary: its share in industrial production has increased from 12.2% in 2000 to 17.3% by 2007, i.e. moved from the 3rd to the 2nd place among sectors. Its revenues are earned overwhelmingly from exports: 90-91% in 2001-2008. Thus its share in manufacturing exports has exceed 25% by 2006-2008 (up from 22-23% in 2001-2005). The industry has a noteworthy 11.5% slice in BERD, and as already mentioned, the share of innovative automotive firms is higher than that of manufacturing firms on average. (KSH) Hence, there has been a strong case to include 6 automotive firms – of which 2 are serving non-automotive clients, too – in the sample so far.

As for ownership, only one of them is an indigenous, middle-sized firm; two are large, green-field investments, another two are large, brown-field investments, and the remaining small one has also been taken over by a foreign company. Two of the foreign investors are non-EU companies. All these automotive firms are suppliers, and are integrated into lean production systems, with the major characteristics described above. Three of them are subsidiaries of T1 suppliers, and they can be classified into three different groups in terms of their activities. One is a T1 supplier 'proper', operating a sizeable R&D centre in Hungary. The second one exhibits a mixture of T1and T2 activities: it possesses so-called global responsibilities for those products, which are exclusively produced in Hungary for the entire group, while for the other products it is more acting as aT2 firm. The third one is mainly introducing new products developed by its parent firm, and engaged in process, managerial and organisational innovations, that is, its behaviour resembles a T2 supplier. The remaining 3 firms are 'pure' T2 suppliers.

> As mentioned above, *new products* are usually brought in by parent firms. However, there are different types of exceptions to this rule. The obvious one is when formalised R&D activities are conducted in Hungary, leading to product innovations. In one such case a new product had been designed and tested in Hungary but then the Engineering Centre was relocated from Hungary – given broader strategic changes, re-allocating responsibilities among plants for the so-called OEM and aftermarket –, and hence this new product was also assigned to a different plant inside the group (outside Europe). Another source of product innovations is reverse engineering, e.g. in the case of spare parts sold on the aftermarket. Incremental innovations are also important from an economic point of view, although these are less spectacular. In these

[13] NACE codes were revised in 2008, but as most recent data available at a 4-digit level are from 2007, the "old" NACE codes are used in this report.

cases the idea might come either from the users, requesting improved performance or from the engineers of a supplier to reduce production costs, energy consumption and environmental burden (e.g. oil used during machining processes) or enhance product characteristics, e.g. by splicing thin metal sheets together instead of welding them. For this latter modification, the entire production process had to be redesigned, purchasing new equipment, introducing new measurement and test methods, too.

In general, *production processes* are designed by the Hungarian subsidiary, assisted to some extent by the parent firm or the suppliers of machinery. In most cases, subsequent process innovations are stemming from local knowledge and experience. Also, it is quite often the case that products brought in by the parent firms need to be modified for more efficient manufacturing, i.e. the sources of these minor product innovations are the Hungarian subsidiaries. A frequent form of process innovation nowadays is the introduction of manufacturing cells, usually designed by the local engineers, trained by the parent firm, and assisted by general principles applied across the various subsidiaries of the group.

As for *organisational innovations*, again, there might be some assistance provided by the parent firms in the form of internal manuals, guidelines and good practices, but local solutions are also encouraged. For example, so-called cross-functional teams have been introduced by an interviewed firm, composed of middle-managers responsible for purchasing, manufacturing, logistics, and quality assurance. These teams are usually co-ordinated by a sales manager, who is representing the firm vis-à-vis the client in all matters, responsible for obtaining and keeping orders, maintaining smooth co-operation with the buyer and inside the firms among the various units, and thus a profitable operation. For indigenous firms, the main sources of organisational innovations are their own ideas and/or external advisors (see above).

Marketing innovations might be of economic relevance, too, especially for suppliers specialising in the aftermarket. One such firm in our sample has established direct contacts with its major buyers (e.g. public transport providers), and thus replaced wholesale companies.

In sum, automotive firms are in fierce competition with their counterparts (assemblers – assemblers; T1 – T1 suppliers; etc.), and thus there are strong incentives to be innovative, i.e. to introduce new products, processes, organisational solutions, management and marketing methods. Moreover, several T1 suppliers, when assess their T2 suppliers' performance include the intensity of innovativeness among the set of evaluation criteria. Our interviews have confirmed the crucial importance of co-operation among subsidiaries of large MNCs, and that of international production networks (in case of independent suppliers). Besides, local knowledge and experience are also important sources of the various types of innovations (technological and non-technological) observed. From a different angle, beyond formalised R&D activities, many other types of knowledge are needed to underpin successful innovations.

Pharmaceuticals

Pharmaceuticals industry is 'the' archetype of a science-based industry: it has the highest level of R&D intensity worldwide (16.1% of revenues was spent on R&D in 2007, and 16.5% in 2008), and is also spending the largest amount on R&D (19.2% and 18.9% of the global R&D expenditures accounted for in 2007 and 2008, respectively). (IRIS [2008], IRIS [2009]) Further, patents are the most important tools to protect intellectual property rights in this industry, and thus there are long time series on patents in many different countries. Given these two factors, pharmaceuticals is among the most intensively studied sectors, both in advanced and developing countries. There are highly specific features of R&D and innovation processes, as well as competition dynamics in this industry – e.g. the nature of search procedures in different technological regimes, lack of cumulativeness in search and development processes, fragmented markets (in terms of therapeutic categories), the role of health authorities, doctors and insurance 'regimes' in shaping markets (by regulating it, registering, prescribing and financing drugs, the role of R&D subsidies and IPR systems – but these are not discussed here in any detail because none of them are specific to Hungary.[14] Only those features are mentioned below, which are essential to summarise the interview findings.

There are two major types R&D and innovation strategies in this sector: (i) developing original drugs; and (ii) producing so-called generics (replica of drugs not protected by patents any more). Pharmaceuticals companies have relied on their in-house R&D units for new molecules (candidates for drugs) and on external sources of knowledge to a varying extent in different periods, and also depending on their strategies. With the advent of biotechnology, universities, government laboratories, and small biotech firms – often span off from the former ones – are becoming more important partners in searching for new drugs. Moreover, the latter partners have also become targets for acquisitions by long-established large pharmaceuticals firms.

The funds required for the development and marketing of a new, original drug has increased drastically over the last decades due to ever more complex clinical testing regulations. While the development of an original pharmaceutical product had cost around €149 m in 1975, its costs increased to €868 m euro by 2000. (AIPM [2006]) Prevailing regulations and requirements in the pharmaceuticals industry, such as the documentation of patent applications, tests required for the registration of new drugs and the qualification of the production technologies significantly increase the costs associated with research and development. For this reason large firms have become the dominant actors in the pharmaceuticals industry.

As already stressed, pharmaceuticals firms spend by far the largest amount on R&D, and it is the most R&D-intensive industry in Hungary, too. The decisive factor to determine R&D and innovation activities is the strategy of multinational firms as foreign professional investors privatised all the major Hungarian pharmaceuticals firms already in the early 1990s, except for Gedeon Richter, which is registered on the Budapest Stock Exchange. More recently, a number of other foreign pharmaceuticals companies have also set up their operation in Hungary as green-field investment. Hence, this sector is dominated by foreign professional investors.

As Gedeon Richter has not been taken over by a foreign professional investor, it is an exception on various accounts. It is still pursuing R&D activities to develop its own drugs, and thus more recently heavily investing in biotech research facilities. Further, it tries to keep its market share in foreign markets on its own, especially in Russia. Thus, the observations presented below are not valid for this company. It should be stresses, as Gedeon Richter is identified by IRIS as the biggest R&D spender in Hungary: with its €69m R&D spending in 2008 it is ranked 217 on the list of top 1000 EU firms. (IRIS [2009]

Foreign ownership has significantly affected the R&D activities and performance of Hungarian pharmaceuticals companies. Besides capital injections, foreign investment has also facilitated the inflow of modern technologies, and procedures like the in vitro method, as well as modern marketing and management techniques. Due to the financial strengths of the parent companies, increased R&D funds have become available, and chances for developing a product from the original molecule and taking it to the market increased – in the case of firms

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[14] Just to pick a few pieces from the huge body of literature, interested readers are referred to Criscuolo [2009]; D'Este [2002]; Gambardella *et al.* [2000]; Geuna [2001]; Henderson *et al.* [1999]; Laforgia *et al.* [2007]; Malerba and Orsenigo L [2002]; Mazzucato and Dosi G (eds) [2006]; McKelvey *et al.* [2004]; Mittra [1997]; Nightingale [2000]; Orsenigo *et al.* [1999]; Orsenigo *et al.* [2001]; Patel [2008]; Patel *et al.* [2008]; Scherer [1993], [2000], [2007] and.

taken over by relatively smaller, family-owned foreign pharmaceuticals companies, pursuing this sort of R&D innovation strategy. The allocation of R&D expenditure has become more efficient and the exploitation rate of research results increased. As Hungarian companies privatised by foreign professional investors have become integrated to the global production networks of their parent companies, international co-operation in R&D activities has become a daily routine. Further, these companies have gained access to export markets via their foreign owners. Given these factors, the competitiveness of Hungarian pharmaceuticals companies has improved. (Reiter [2005])

The foreign investors have also significantly restructured the R&D units of their Central European affiliates. The number of research personnel had decreased – in Hungary from 1629 in 1998 to 1577 in 2002, and then increased from 1681 in 2003 to 2134 in 2007. (Eurostat) In most cases, the global R&D strategy of the parent companies determines what type of research is to be performed by their Hungarian affiliates. In many cases, the foreign owners reorganised the R&D activities of their Hungarian subsidiaries to improve cost-efficiency at the level of the enterprise group (TNC). Hence, R&D at the Hungarian subsidiaries is restricted to areas specified in the global R&D strategy, and research aimed at identifying original molecules is restricted to only a few specific areas, in a few companies. The number of patent applications for original products has, therefore, decreased.[15] From a different angle, major decisions on R&D and innovation are made by distant headquarters, and the autonomy of Hungarian researchers has diminished drastically. Another significant effect is that co-operation between domestic companies and universities has become more limited, and it is performed mainly in the field of developing analytical tests. Finally, the product portfolio of Hungarian affiliates has become narrower in many cases, because the parent company has replaced Hungarian products by its own drugs.[16]

Clinical trials are the most costly, uncertain and time-consuming parts of the process leading to a new drug. Interviews suggest that the bulk of R&D funds spent in Hungary by foreign firms is financing various stages of clinical trials. The main advantage for them is a faster completion of these projects in Hungary. First, patients are more willing to participate in clinical trials than in Western countries, because they are less concerned of risks, and have stronger incentives to get access to modern, expensive drugs in this way. Thus, required samples can be found more quickly. Second, clinics (doctors) are also more interested in this type of R&D. They can be involved in advanced projects, obtaining knowledge on exciting developments, and generate revenues, too. As for the pharmaceuticals companies, gaining a year, or so, is a huge advantage: patent protection is usually granted for 10 years, and clinical trials need to be completed in this period. Faster clinical trials, therefore, can be seen as an 'extension' of the temporary monopoly enjoyed by original drugs, leading to notably increased revenues. Clinical trials are usually also cheaper in Hungary, but this is of secondary importance, compared to faster completion.

There is no specialisation in terms of diseases – market segments – among the subsidiaries of the same TNC. On the contrary, affiliates have to compete for these projects. The main selection criteria are the capabilities to obtain an appropriate sample of patients, to "manage" the sample in terms of complying with the quality criteria, and to process data at the required level.

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[15] Another major explanatory factor is the introduction of product patents – replacing process patents, which had been used to circumvent the protection of drugs developed by other companies. Given this transition from the process-patent to a product-patent system, Hungarian manufacturers had to introduce a dramatically new approach to research. As for the impacts of regulatory changes on R&D activities, see, e.g. Athreye *et al.* [2009].

[16] This brief account is based on mini case studies prepared for Havas [2006].

As for the division of labour between the parent firms and subsidiaries concerning the clinical trial processes, the overall plan is devised by the headquarters, whereas the study design concept, protocols, additional documentation are prepared by the subsidiary in many cases. The draft protocol is always co-ordinated with the subsidiary, and on that basis it elaborated the final protocol. Analysis and evaluation of results also takes place at the local level. Fundamental tasks of the local branch (during before and during implementation) include the following: budgeting, dealing with local suppliers, dealing with local regulations and permits, contracting (e.g. CROs, doctors, patient groups), data verification, data cleaning, etc. It also means that some of the employees of the R&D units of these Hungarian pharmaceuticals firms are not trained as researchers (chemists, biologists or medical doctors); they can be teachers or middle-managers, who are good enough in performing the tasks listed above, or have sufficient skills in data processing.

Our limited exercise cannot provide an overall estimation on the skills (and tasks) composition of the R&D staff of these companies specialising in clinical trials, but this observation might be an important consideration from a policy point of view. Obviously, a broader coverage would be needed to establish the policy relevance of these facts.

Several interviews have indicated that in spite of strict regulations, innovations are possible and important even for clinical trials. *Process and organisational innovations* can improve efficiency by cutting costs and speeding up various stages of clinical trials.

> One interviewed firm has “merged” the various phases of clinical trials and also reduced the number of different “test lines” (e.g. from 5 to 3) in later phases, and hence eliminated unnecessary investigations.
>
> Other examples of process innovations – in most cases developed by competitors and/or in other markets by the parent company, but new to the Hungarian firm or even on the local market – include:
>
> - electronic data collection during the clinical trial process
> - application of biomarkers in the experimental phase.

An innovative way of using clinical trials (not required by regulation) has been introduced by another interviewed firm. By comparing two different drugs using the strict protocol of clinical trials their aim has been to demonstrate the superiority of their own products, and then convince both the health authorities and doctors that it is more effective and efficient to use this particular medicine. In brief, clinical trial can be used as a marketing tool, in effect to defend market shares when IPR protection would expire, and competitors offering cheaper generics would enter.

As prescription (OCT) drugs cannot be advertised, marketing innovations are crucial tools to increase market shares and raise revenues. One of the interviewed companies is particularly creative in that respect. They have co-operated very closely with patient groups in organising health awareness campaigns concerning various illnesses, for which they offer drugs.

> In this novel way they provide first hand information to the targeted patient group and a marketing campaign at the same time. As part of these promotional activities, the involved doctors also receive detailed information on the effectiveness of the respective drug. Moreover, they have organised free-of-charge screening services in several locations, and thus obtained data on tens of thousands of patients.
>
> These campaigns are perceived as highly useful by patients, doctors and the health authorities. E.g. this way they can help in bridging the communication gap between doctors and patients in the case of those diseases, which are less known among the population, and hence trust between the patients and doctors is key.

> The first national conference for patient organisations, organised in 2007, was co-sponsored by this company, where they also put up information booth, organised screening, etc. These efforts were followed up in 2008, when a professional conference was organised, involving officials from the Ministry of Health.

Yet another interviewed company is an exceptional case as it conducts two types of R&D activities in Hungary: aimed at developing original drugs and generics, as well.

> These two activities are completely independent of each other (even located in different cities), and there is no R&D co-operation between the two Hungarian divisions. The small R&D unit working on original drugs collaborates its counterpart at the headquarters of the parent firm. These types of R&D activities, however, have been scaled down since 2007, given a strategic move of the parent firms, followed by many other drug manufacturers, too. Nowadays these companies seek to acquire molecule licences at a later stage of their development from research institutes, universities or other labs to reduce uncertainties and related costs. The Hungarian subsidiary might also suggest 'candidate' molecules, although it is not among its main tasks. Strategic decisions regarding the acquisitions of molecules are made by the parent firm.

> Hungarian researchers have improved the quality of a biological drug thanks to a successful process innovation, conducted in co-operation with colleagues at the headquarters. There are 2-3 different methods for manufacturing the required compound. In 2008 a new (more reliable, and more stable) method was developed. Since it is a biological drug, the production and the certification processes are much more complex than those for small molecule drugs (which can be mass produced). For all manufactured "batches" of this drug it has to be documented that all batches are equivalent with the one accepted during the registration process. The method that proves this equivalence is the innovative part of the new process. Development of such methods typically takes 2-3 years, and need to be approved by the relevant authorities.

A number of further research questions would worth thorough analyses, relying on a broader sample, and more detailed firm-level case studies (as opposed to single interviews):

- a deeper understanding of the differences in R&D and innovation strategies of different firms (e.g. the ones privatised by professional investors vs. registered at the stock exchange; the ones privatised by large vs. medium-sized foreign professional investors, brown-field vs. green-field investments); leading to a taxonomy of firms and their strategy, and explaining the links between strategies and performance
- to what extent path-dependency and cumulativeness is characteristic in this case, where sweeping changes have occurred in ownership structures, and a fundamentally new IPR system has been introduced in Hungary, while a new science base is emerging in the sector in general, leading to new inter-firm and university-industry co-operation patterns and a new rationale for mergers and acquisitions
- the impacts of various non-STI policies on pharmaceuticals R&D activities, the ones by narrowly defined economic policies, aimed at cutting (or at least controlling) the rocketing health care budget; regulations doctors' prescribing practice; the overall organisational and institutional system of health care and insurance, etc.

Information and Communication Technologies

Information and Communication Technologies (ICT) is a commonly used notion to bring together several economic sectors, as their products and services rely on these technologies. Depending on the purpose of a given analysis, various sectors could be grouped together under this heading, usually hardware and software companies, as well as service providers. In general, these sectors are regarded as science-based industries or knowledge-intensive services. Moreover, several publications of influential international organisations indicate a certain level of hype surrounding these sectors/ technologies. Just to highlight a few: "A New

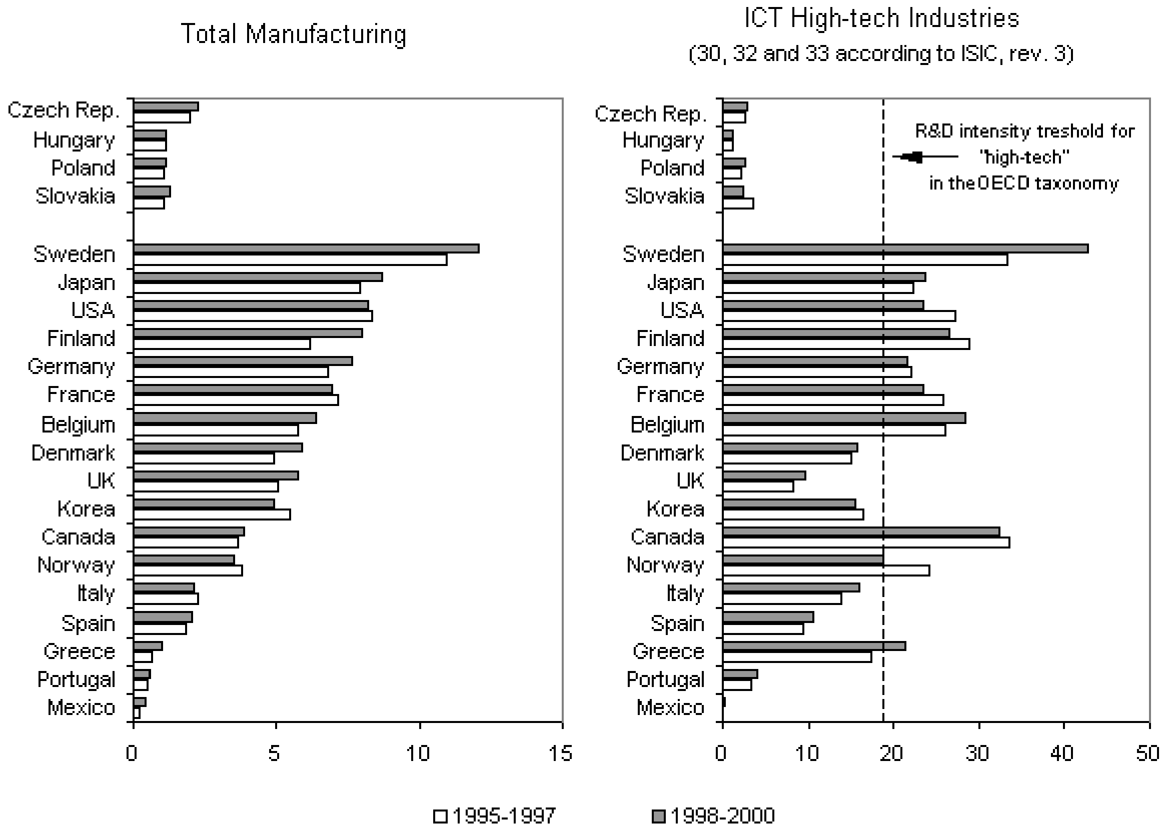
Economy? The Changing Role of Innovation and Information Technology in Growth" (OECD, 2000), "Drivers of Growth: Information Technology, Innovation and Entrepreneurship" (OECD, 2001). These titles are understood by many policy-makers that innovation is identical with R&D (or science), and the latter one, in turn, equals high-tech, mainly information and communication technologies (ICT). This misconception is reinforced by a number of recently introduced indicators and measurement methods, heavily stressing the importance of 'high-tech', although these indicators and their use are highly questionable.[17] While the notion of 'new economy' is totally discredited by now, more recently the phenomenon of open source software has been extended into a new, general buzz word, namely 'open innovation', and 'diffused' highly successfully in the literature, as well as among policy-makers. In sum, ICT has been (mis)used as a launching pad for several hypes and myths, or to put it more mildly, dubious notions leading to deceptive policy implications.[18]

Even a simple look at basic statistics would question the myth about the high-tech nature of ICT. The R&D intensity of firms and the same ICT sectors across countries vary greatly. Several ICT firms are indeed among the top R&D performers (IRIS [2008], [2009]), while many others are 'screw-driving' plants, and do not perform any R&D activity. These firm-level differences are reflected at a sectoral level, too. R&D-intensive industries (or services), as classified by the OECD, are not necessarily R&D-intensive ones in all countries. Srholec [2006] clearly shows that the actual R&D intensities of the so-called ICT high-tech industries were way below the OECD high-tech threshold in 1995-2000 in a large number of OECD member states: all the four Central European member states, as well as Denmark, Italy, Korea, Mexico, Portugal and Spain. What is even more striking, the R&D intensity of the high-tech ICT sectors was below the average R&D intensity of manufacturing industry in the four Central European countries. (Figure 4) Thus, it would be a gross mistake to regard these sectors as 'technology leaders' – with all the assumed positive impacts on growth and competitiveness – in these countries.

[17] On measurement issues, see, e.g. Godin [2004], Smith [2004], as well as a series of working papers at http://www.csiic.ca/Pubs_Histoire.html.

[18] Given the promised role of biotechnology, myths are abundant around pharmaceuticals, too. Nightingale and Martin [2004] offer a sobering account on these myths.

Figure 4: R&D Intensity in Manufacturing in the OECD Countries during 1995-2000 (BERD on value added in %)



Source: Srholec [2006], based on OECD data

Note: BERD (Expenditure on R&D in the Business Enterprise Sector) is not available for ISIC 30 in Finland in 1998-2000 Japan in both periods, for ISIC 32 in USA in 1995-1997 and for ISIC 33 in Canada and Mexico in both periods.

Case studies also indicate substantial differences among the activities of ICT firms in terms of R&D and knowledge-intensity. Even the very same firm at the same plant is likely to perform many different activities with diverse levels of R&D intensity.[19] When we compare plants of a given firms located in different countries, these differences can be even more pronounced. The same applies when we consider different firms – although statistically belonging to the same sector.

Indeed, ICT hardware manufacturers can be characterised by a deep, highly structured division of labour (e.g. PC manufacturers – chip manufacturers), with the players pursuing distinct R&D of innovation strategies. Moreover, the role of the so-called contract manufacturers has become dominant (Sturgeon [2002]; Sturgeon and Lee [2001]), and that has introduced further elements of complexity in the division of labour, including competences of, and responsibilities for, R&D and innovation activities along the value chain.

If we take the broader spectrum of ICT firms, that is, hardware, software, and service provider firms – and also the different types of software and service provider firms inside this large group –, a sound analysis should be based on a thorough understanding of an even richer diversity in the nature of RTDI processes, and hence firms' strategies.

[19] The same observation could be made when using the broader concept of the knowledge content of a given activity.

This diversity among ICT firms can also be observed in Hungary. Three major telecom equipment manufacturing MNCs have Hungarian subsidiaries, all performing R&D and production operations (to a different extent, though). Several major contract manufacturing MNCs also have plants in Hungary, and a former major indigenous electronics firm (used to have its own brand products) has been revived from its ashes by transforming it into a contract manufacturer. Besides, lots of small and medium-sized firms are producing ICT products and components, developing and distributing software or offering services (e.g. consultancy and tailoring software packages to specific needs of government agencies, other public bodies and firms). Needles to stress, there are substantial differences among these firms in terms of R&D intensity, R&D and innovation strategies and activities, as well as patterns of co-operation.

The limited number of interviews cannot fully reflect this diversity, but some elements can be captured by selecting different 'species', and new colours can be added to this picture. Four firms have been interviewed in these sectors: a subsidiary of a major telecom equipment manufacturing MNC; the manufacturing 'arm' of a foreign-owned firm specialising in PC-based scientific instruments; a software developer; and a spin-off firm engaged in developing tactile sensor technologies and related software.

This latter case clearly shows that sectoral characteristics override ownership patterns: given the research intensity of the technological fields in which this firm is active, a small, domestic firms is not only conducting potentially path-breaking R&D projects, but already are in negotiations with the NASA, Boeing, and a major computer game software developer, as well as medical equipment manufacturers and surgical teams abroad.

The software developer, established 25 years ago, is serving a special market segment: it supports technical professionals with a bespoke package. They are active both in product and marketing innovations.

> Their flagship product is being continuously developed, and major upgrades are released regularly, in every 12-18 months. These different versions represent different type of product innovations. E.g. the version released in 2008 has been tailored for multi-processor workstations to increase performance. (As of autumn 2009 this was the only software package in this market segment with this feature.) This type of innovation is 'under the skin' for the users, while other types of upgrades can be termed 'functional innovations'. A major improvement of this kind was patented in 2007: the so-called virtual trace function provides a tool to create 3D documentation from the 2D 'layers'. Engineers used to work on paper, in 2D. To create 3D views, they applied transparent paper, placing several layers of these 2D design sheets on each other. Now they directly feel this new function – as opposed to the other, 'under the skin' technical improvements –, and would certainly appreciate it. A more recent development is in between 'pure technical enhancement' and 'functional' innovations. The latest version of their product supports team work by introducing a server-based database (instead of files), offering more reliable and secure, faster and more flexible access to data for those engineers who work in a team on a large(r) design project. (Around 20-30% of their customers work for large companies, where team work is more likely than at SMEs.)
>
> *Marketing innovations* are also crucial to maintain their competitiveness. A new business model was introduced in certain markets in 2001: customers may choose 'subscription to permanent support', as opposed to buying the new versions of the product. In this new model the customer enters in to a long-term service agreement with company, paying an annual fee for continuous support services (consultancy, maintenance, etc.), and receiving the latest (usually yearly) upgrades of the software package. In this way revenues can be planned more reliably, and thus the financial conditions for product development are becoming more stable. (The basics of this business model had been first introduced just 3-4 years before this company.)

> A combination of marketing and organisational innovations is the use of two main sales models. As around 99.5% of revenues are stemming from the export markets, finding the right sales methods and channels is of crucial importance. In several countries local subsidiaries are responsible for sales activities in their respective markets, with sales being their exclusive task. In other countries the company contracts local, individual distributor agents. To some extent even these independent sales agent influence product development by providing regular and systematic feedback from the users. These are important inputs, as local design routines – or other context- and culture-specific features – need to be taken into account during the product development process. All in all, the company works with dedicated distributors in 80 countries and hundreds of Value-Added Resellers (VARs) and Systems Integrators who provide personalised consultancy services to customers.

One of the major lessons gained from the interview with a subsidiary of a major telecom equipment manufacturing MNC is that substantial R&D activities (in terms of financial and human resources) could be 'decoupled' from other local activities (production, sales), as the former ones are serving either strategic R&D objectives or actual product development projects defined at the group level. (see also sub-section 4.3.2) Hence, it would be misleading to quantify the impacts of R&D activities on productivity or profits at the level of this subsidiary. The relevant unit of analysis is the group itself. (Other lessons are utilised in sub-sections 4.3.3 and 4.3.5.)

The manufacturing 'arm' of a foreign-owned firm specialising in PC-based scientific instruments had originally been meant as a pure manufacturing plant in a low-cost production base. Then gradually several R&D, engineering and innovation activities have evolved fairly quickly: first to support production processes, then upgrade/ modify existing products (e.g. the replacement of several components to make lead-free soldering possible), and finally to enhance the efficiency of testing – a crucial act in this business – by designing new, modular test racks, capable of testing a much wider variety of instruments, and thus speeding up production (the line need not to b e stopped for changing the test rack). Further R&D activities are also planned to be conducted, and thus the number engineers employed for these tasks might increase from the current 20 to 30-40 in a few years.

As another type of innovation, this firm has also applied the basic principles of lean manufacturing to cut costs, and as an element of these changes, U-shape manufacturing has been introduced. In this way, the number of personnel engaged in certain production processes has been reduced. Yet, these people have not been laid off, because training them is time-consuming and costly. Hence, they have been given new tasks.

4.3.2 A refined taxonomy of the role of RTDI activities in the overall business strategy of foreign-owned firms

A growing number of major foreign companies have expanded their existing R&D units or set up new ones in Hungary since the mid-1990s. Earlier research has suggested that for analytical purposes and from the point of view of policy relevance four types of strategies can be distinguished concerning the role and 'weight' of RTDI activities in the overall business models of foreign-owned firms. The impacts of these distinct strategies on the national innovation system of host country, and in particular on the indigenous firms' RTDI activities and learning capabilities would be different. (Havas [2004])

Interviews conducted for the Micro-Dyn project have confirmed this tentative taxonomy, but a fifth type of strategy has also been identified. Several foreign-owned firms have set up R&D units in Hungary, and also performs production activities, but these are 'disjoint': R&D activities are mainly conducted as parts of group-level R&D projects, serving the global market, and practically have no connection to other activities serving the domestic market.

Taking into account this Micro-Dyn finding, a revised taxonomy can be summarised as follows:

1) *Narrowly defined efficiency and/ or market seeking FDI with no R&D conducted in the host country*
   In these cases product innovations are underpinned by R&D activities conducted at other sites – often in the home country – of the investor. Process innovations would also rely on the experience accumulated at other sites, but in the case of brown-field investments domestic skills and knowledge might play a role. As for organisational, management and marketing innovations, the main source would be again the codified and tacit knowledge of the foreign managers. These innovation efforts would enhance the productivity of a given site, but hardly any impact can be expected on the other players of the domestic NIS, except for spillover effects, proper.[20]
2) *R&D 'contracted out' by the headquarters* (without having domestic production activities)
   These units conduct R&D projects to cut costs, compensate for the lack of researchers in the home country, or seek other advantages (e.g. faster clinical trials). They are, however, stand alone entities, and in most cases not linked to local R&D institutes or indigenous firms. These units, therefore, have an almost negligible impact on the national innovation system. An important exception is when small Hungarian R&D units of foreign-owned pharmaceuticals firms organise clinical trials: by definition, they must co-operate with local clinics, and in several cases they also co-operated with CROs (contract research organisations).
3) *'Disjoint' domestic production and R&D*
   These units also conduct R&D projects to cut costs, compensate for the lack of researchers in the home country, or seek other advantages. These R&D activities are, however, not linked to local production activities. Collaboration with other local R&D institutes or university departments can be observed, as opposed to Type 2) strategies. These units, therefore, might have some noticeable impacts on the national innovation system (e.g. via shaping curricula, offering professional and financial support fro PhD programmes).
4) *R&D activities to underpin local manufacturing or service activities*
   Some of these R&D units work exclusively on intra-mural projects, relying on internal knowledge (possessed by the parent firm, developed either in the host or home country or at other sites). Others co-operate with local universities or R&D institutes to exploit external knowledge sources. Obviously, the former ones have not affect on the domestic NIS, while the latter ones contribute to joint knowledge generation and exploitation processes.
5) *Deep integration*: RTDI efforts for both local and global projects
   These firms – and their R&D units – are engaged in both local and global RTDI efforts and thus have close links with the local knowledge bases, too, bringing them into their international networks. This group is smaller in number than 'type 3' R&D units, and hence their impacts on the NIS should not be exaggerated. Yet, it should not be underestimated, either: their behavioural norms, management methods and the overall mode of operation can have important 'demonstration effects' through their interaction with the local players, and lead to 'learning by co-operation'.

[20] On the complexity of spillover issues, see, e.g. Breschi and Lissoni [2001] and Langlois and Robertson [1996]. Empirical analyses usually follow a different approach, e.g. Damijan et al. [2003].

4.3.3 Academia-industry collaboration

Interviews have confirmed that companies and public R&D units (PROs) are driven by fundamentally different incentives to be involved R&D and innovation activities. Hence, there are inherent hindrances to academia-industry collaboration – one of the weak points of the Hungarian NIS, as already discussed in Section 3. In brief, companies are interested in a relatively wide array of R&D activities (from day-to-day problem solving to long-term strategic research), but those lead to business results (enhanced productivity, larger market shares, entry to new markets, increased profits). Thus, tight project management (e.g. meeting deadlines and 'respecting' budget constraints) and keeping commercially sensible information secret are of vital importance. In contrast, researchers working for universities and other publicly financed research units are not only interested, but even forced to disclose their results. Further, they are less accustomed to tight project management.

Certain types of co-operation have been observed, however. Any research-intensive spin-off firms would naturally co-operate closely with those research units where founders used to work (or still keep a part-time position). Yet, the only firm in our sample has indicated certain frictions in co-operation, given the rigid structures and slow decision-making at the public research institutes.

Almost all medium-sized interviewed firms reported R&D co-operation with universities and/or PROs, especially with those located nearby. In all these cases there has been a pragmatic technical objective – a certain problem to be solved, a new production process to be introduced, etc. –, and a public support measure has also been exploited. (Several Hungarian STI policy measures either make academia-industry co-operation compulsory, or this type of project proposals are given priority.)

Larger firms tend to be more interested in co-operating with universities and PROs on strategic, long-term R&D projects to explore new technological opportunities, reducing both the costs and risks by co-operation. They also support PhD courses financially and/or offering PhD students relevant themes (projects) for their thesis. (A broader form of co-operation is supporting tertiary training by donating modern equipment to universities, and hence making sure that the next generation of engineers and scientists would be familiar e.g. with up-to-date measurement techniques and other relevant instruments.)

In sum, different firms are faced with different needs, and thus pursue different RTDI strategies. Hence, different forms and types of academia-industry co-operation can be observed, with specific goals and activities. STI policies, however, tend to neglect this diversity.

4.3.4 The role of users in innovation

Interviews have also given detailed insights on the decisive role played by users in innovation processes in certain industries (specific software packages, hand tools). This is a thoroughly researched topic, and the findings of these M-D interviews are in line of the literature (see e.g. the works of von Hippel).

4.3.5 The use and impacts of domestic and EU STI policy measures

Interviews suggest a surprisingly low importance of domestic and EU STI policy measures – but a caveat is in place immediately: this is a very small, non-representative sample. Several firms, however, have exploited grants offered by these schemes. Practically all cases the project had already been decided; i.e. the scheme in question has not oriented the RTDI activities of a given firm. Moreover, most of these projects would have been conducted without public support, too. On other words, additionality in the narrow sense has been fairly low. More detailed case studies would be needed to establish if additionality in the broader sense – the so-called behavioural additionality – has occurred in any of these cases. (Lipsey and Carlaw [1998]; OECD [2006])

It should be also stressed that consultancy firms specialising in identifying opportunities to obtain public support and drafting project proposals have played a major role in several cases. Without them a number of firms have not applied for public support. Again, more thorough research, relying on a larger sample, would be needed to draw firm policy conclusions. So far, only diametrically opposite interpretations can be put forward as hypotheses. A) These firms play a useful role in 're-wiring' and revitalising the Hungarian NIS: they disseminate vital information and build contacts among the interested players more efficiently than the responsible government agencies and other public (non-profit) organisations charged with these tasks. B) These firms pursue a special rent-seeking strategy, and appropriate some 10-15% of public funds meant to be used for advancing societally good courses.

4.3.6 Impacts of the global crisis

Our limited sample has suggested significant differences across sectors concerning the impacts of the global financial and economic crisis. Some sectors have been hit particularly hard, e.g. automotive firms, while others have been 'sheltered', given fundamentally different nature of their markets, most notably pharmaceuticals.

More importantly, there has been marked differences in terms of the importance of innovation as a response to the crisis (e.g. devoting more resources to R&D in order to speed up the introduction of new products, cutting costs by process innovations) inside a given sector (ICT).

5 IMPLICATIONS

Even this small sample offer several methodological and policy implications, which are highlighted below.

5.1 Implications for innovation surveys

Some standard questions of innovation surveys might need some revision or more detailed interpretation in 'fast-moving' sectors (e.g. when the main product is changed every year or products tend to have a 3-year life time). In these sectors practically all firms would be innovative ('innovation-active') using the definition of the Community Innovation Survey (CIS). Obviously, a more refined terminology would be required to underpin theoretically relevant analyses, which in turn can be' translated' into sensible policy conclusions.

Interviews have also showed that managers have different understanding of innovation (being innovative). In almost all cases it has been crucial to explain the CIS definition in detail: otherwise they would have declared their firm non-innovative. Hence, it would be useful to run a specific project to check the 'validity' and quality of CIS results. How those managers understand/ interpret innovation who reply to CIS questionnaires on their own, relying on only the written definition. Given this question, this project can only be based on face-to face interviews, and thus would be rather costly. Yet, the opportunity cost – devising policy measures based on false information – is likely to exceed these costs significantly. One more caveat: there might be major differences in this respect across countries (more developed ones, in general, and having accumulated more experience with running CIS and analysing its results vs. less developed ones and/ or less experienced ones), as well as among firms (with different level of R&D and innovation intensity, and/ or managerial skills).

5.2 Implications for quantitative analyses

In case of 'disjoint' R&D and production (when there is no link between R&D efforts conducted in the host country and the subsidiary's economic performance) the unit of analysis cannot be the local subsidiary. It would be important to establish to what extent this phenomenon would influence ('distort') the results of econometric analyses.

Interviews have also revealed that in some cases R&D is conducted in Hungary, but financed directly by the parent firm (e.g. some clinical trials). These activities simply cannot be analysed by using census and R&D survey data. Again, it would be useful to know to what extent this phenomenon would influence ('distort') the results of econometric analyses.

5.3 Implications for policy analyses and policy actions

Interviews have also raised several questions for further research:

- What room is left for policies when FDI plays a dominant role in the host economy?
- How, why and to what extent to promote "disjoint" R&D activities, conducted for MNCs? Guided by what policy rationale? To what extent is it beneficial for the public?
- As for academia-industry collaboration, a strong need has emerged for more refined measures, better tuned to the needs of the actors (based on a relevant taxonomy of academia-industry collaboration).
  Further, evaluation criteria for academics should also be revised to remove some major obstacles, currently blocking more effective academia-industry co-operation. Obviously, it would require sound analyses and then thorough decision-preparatory process because quite naturally a fierce opposition is likely from academics, given strong traditions at universities and PROs. (Academic freedom is even 'carved in stones' in Hungary: it is a constitutional right – and already has been used as a powerful weapon to deny reforms in the higher education sector.)
- Spin-off companies are faced with several important challenges in Hungary, including heavy regulatory and tax burdens, difficulties in receiving external funding, operating under the ownership of universities or PROs with a different – not business friendly – management culture, the complicated, cumbersome nature of public R&D support measures. How to remove these obstacles – but also avoiding the hypes of venture capital and new technology based firms?

Finally, an important policy lesson can be drawn from the discussion on the so-called high-tech sectors vs. knowledge-intensive activities. STI policies aimed at promoting innovation and hence competitiveness should focus on the actual activities performed, rather than confusing them with the OECD classification of sectors. More precisely, four levels should be distinguished: activities, products, firms and sectors. Firms belonging to the same statistical sector might possess quite different capabilities, e.g. innovation, production, management, marketing and financial ones. Further, they are unlikely to produce identical goods, e.g. in terms of skills and investment requirement, quality, market and profit opportunities. Finally, they perform different activities, especially in their knowledge-intensity. These dissimilarities are likely to be even more pronounced when we analyse sectors, firms, products and activities across different national systems of innovation and production. In short, the performance of heterogeneous firms cannot be improved by uniform policy approaches. No doubts, it sounds elementary; yet policy-makers tend to prefer ‘broad’, general policy tools: they are less willing to pay attention to the above crucial differences among firms in the same statistical sector, and thus even less ready to devise and operate differentiated schemes.

Even highly respected scholars could make this mistake, as pointed out by Archibugi [2001], when commenting on Pavitt’s classic taxonomy of innovating firms: “… the taxonomy is devoted to classifying firms and not industries (…). Unfortunately, Pavitt himself has failed to make this aspect clear: in his 1984 article, as well as in his further developments, Pavitt has grouped in each category of his taxonomy data at the *industry* and not at the *firm* level. This is a major limitation since it is well known that firms which have for convenience been grouped together into an industry on the basis of their main output may have a very different technological base: both slippers and moon-boots belong to the footwear industry, but the technology-intensity of the two products is very different (…).” (p. 419). This example should not be dismissed as a witty, but extreme, and thus irrelevant remark. Indeed, the author also shows that this seemingly small, unimportant mistake may “… lead to wrong policy advice; suppose that a government (…) makes an attempt to foster innovation by using different incentives for each group of firms. If selectivity criteria are applied on the basis of industry to which a firm belongs it is likely that a substantial part of incentives to innovation will be misplaced: for example, moon-boot manufacturers may receive incentives to purchase specialised machinery [as follows from Pavitt’s taxonomy for footwear companies – A.H.] rather than to finance their in-house R&D.” (p. 420)

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