Chapter 2

Performance in science, technology and innovation in an international comparison

This chapter provides an overview of Slovenia's innovation inputs and outputs and compares them with other OECD and EU countries, notably the new EU member states in central and eastern Europe and more developed small economies. For inputs, the comparatively high absolute level and constant evolution of gross expenditure on research and development, with a high industrial share, ensure it a good position. The chapter also shows Slovenia's emphasis on increasing publications, and to a lesser degree patents, with some impact measures still at a low level. Finally, the overall efficiency of the Slovenian innovation system is assessed in comparison with other countries.

The statistical data for Israel are supplied by and under the responsibility of the relevant Israeli authorities. The use of such data by the OECD is without prejudice to the status of the Golan Heights, East Jerusalem and Israeli settlements in the West Bank under the terms of international law.

2.1. Innovation inputs

Slovenia's innovation performance is varied. Some innovation inputs, notably R&D expenditure and the number of researchers per million inhabitants, are broadly on par with or even high relative to Slovenia's GDP per capita. Its overall R&D intensity (R&D expenditure as a share of GDP) was slightly below the EU27 average in 2008 (1.7% as against 1.9%) but increased to almost 1.9% in 2009 (Table 2.1), partly owing to the sharp contraction in GDP in that year (MHEST, 2010; OECD, 2011). Slovenia invests a larger percentage of its GDP in R&D than the Czech Republic, Greece, Italy, Luxembourg, New Zealand, Norway, Portugal and Spain, countries with similar or even higher levels of GDP per capita. No other country in central and eastern Europe boasts R&D intensity comparable to Slovenia's.

Table 2.1. Slovenia's gross domestic expenditure on R&D, current prices, 2000-09

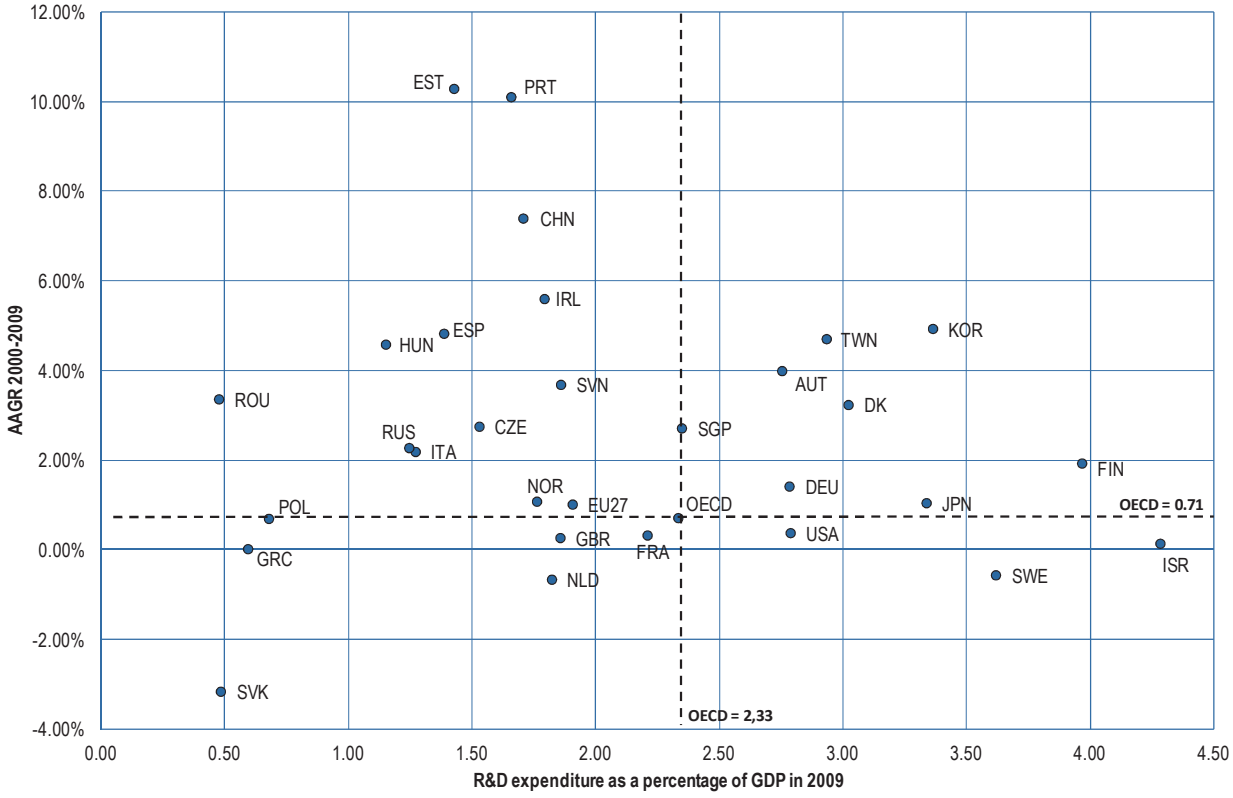
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
In million EUR	256	310	339	320	380	413	484	500	617	657
GERD per capita	128	155	170	160	190	206.5	242	250	308	322
% of GDP	1.41	1.52	1.49	1.3	1.42	1.46	1.59	1.45	1.66	1.86

Source: OECD (2011).

The evolution of R&D expenditure differed from that of other countries in the region. Gross domestic expenditure on R&D (GERD) was slashed in most central and eastern European countries in the transitional phase of the 1990s. In the Czech Republic and the Slovak Republic GERD had fallen to a quarter of official pre-transition levels by 1995 (Meske, 2004, p. 382). Other countries experienced similar declines, aggravated by a massive brain drain as the economy contracted. In the second half of the 1990s research budgets in the region began to recover, although at a very slow pace. Levels have risen in most countries but remain far from European mainstream levels. However, Slovenia's R&D intensity has remained remarkably stable within a band of 1.3% to 1.8% over 20 years. As industrial R&D shrank in the 1990s, public expenditures were deliberately increased in order to maintain research facilities and to minimise brain drain (Bucar *et al*., 2010, p. 31; see also Bucar and Stanovnik, 1999). The share of business R&D has rebounded strongly over the last years. Its share of GDP increased from 0.79% to 1.08% between 2005 and 2009 (OECD, 2011, p. 34).

Figure 2.1 plots selected countries' R&D intensity on the horizontal axis and the corresponding average annual growth rate (AAGR) in R&D intensity on the vertical axis along with the corresponding OECD averages. In 2009, the OECD average R&D intensity stood at 2.33%, and the average annual increase between 2000 and 2009 was 0.71%. While Slovenia's R&D intensity at 1.86% was still below the OECD average, it recorded an AAGR of 3.69%, well above the OECD average of 0.71%. Overall the average annual growth of R&D expenditure during 2000-09 was 3.7%, more than that of the Czech Republic (2.7%), Singapore (2.7%) and Finland (1.9%), similar to that of Austria (4.0%) and Denmark (3.2%), less than that of Hungary (4.6%) and much less than that of Estonia (10.3%), Portugal (10.1%) or China (7.4%) (OECD, 2011).

Figure 2.1. R&D intensity, 2009 level and average annual growth rate, 2000-09, selected countries



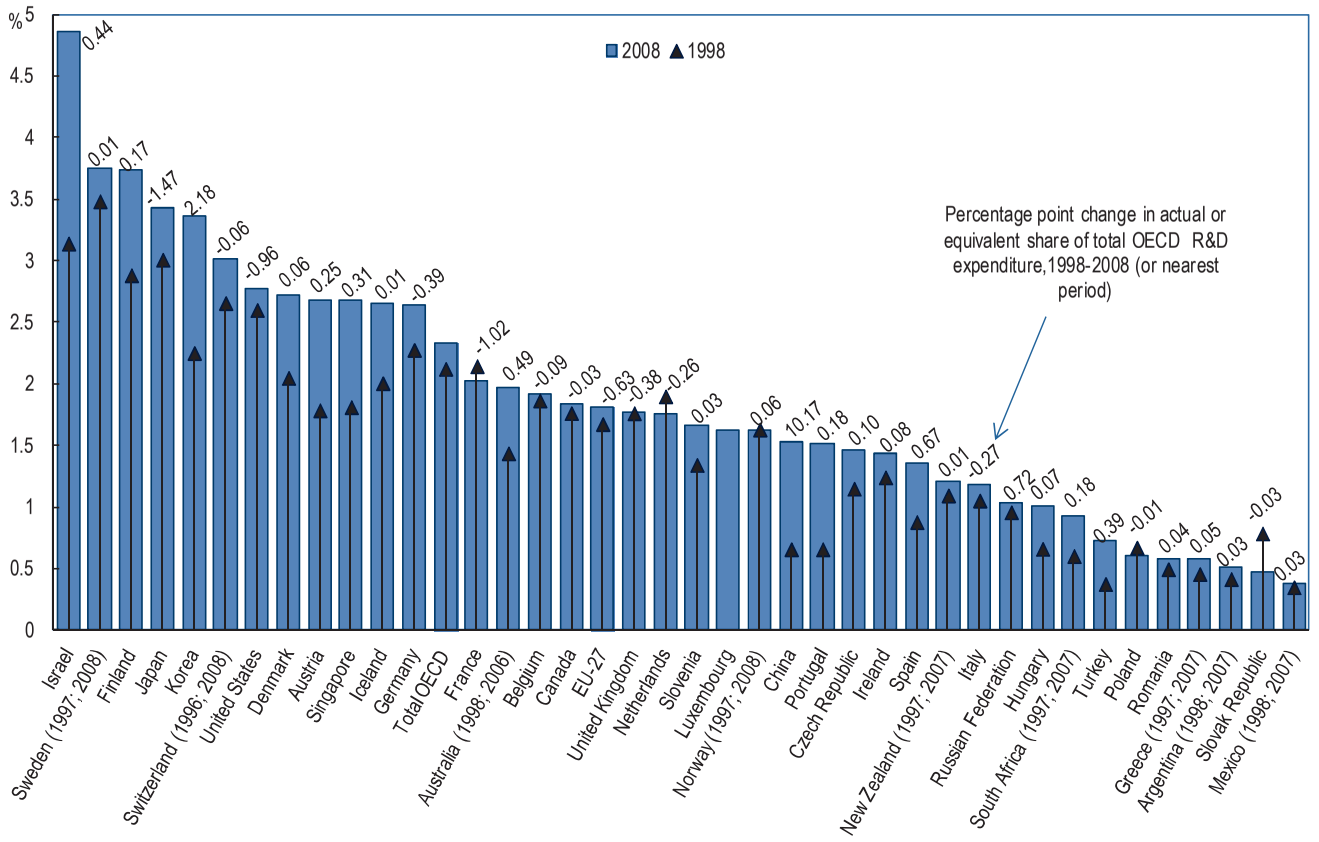
Source: OECD (2011).

The business and public sectors contributed equally to growth. However this was not enough to raise aggregate R&D intensity which stagnated during 2002-07, leaving Slovenia in a group of "trailers" (Eurostat, 2010, p. 43), with R&D intensity around or below the EU average (Figure 2.2). Slovenia is in a better position than Hungary, but was less dynamic than the Czech Republic where R&D was growing faster than GDP by 5% a year; or Estonia, which started from a much lower base but had annual growth rates in the range of 10%. Figure 2.2 further illustrates the evolution of Slovenia's relative position over time in terms of GERD. Most OECD countries have experienced increasing R&D intensity, notably smaller and emerging economies.

Within aggregate R&D, the business sector's contribution gained in importance in recent years,[1] at least until the onset of the crisis in 2008. At nearly 60% in 2007 and 63% in 2008 (Eurostat, 2010, p. 45; Bucar *et al*., 2010, p. 33) business funding of R&D far exceeded the EU27 average of 55% and is thus in a range typical of more advanced innovation systems (Figure 2.3). The performance patterns are very similar to the sectoral shares in the financing of R&D. Much R&D is performed in the business enterprise sector and is concentrated in manufacturing.

Figure 2.2. GERD as a percentage of GDP, selected countries

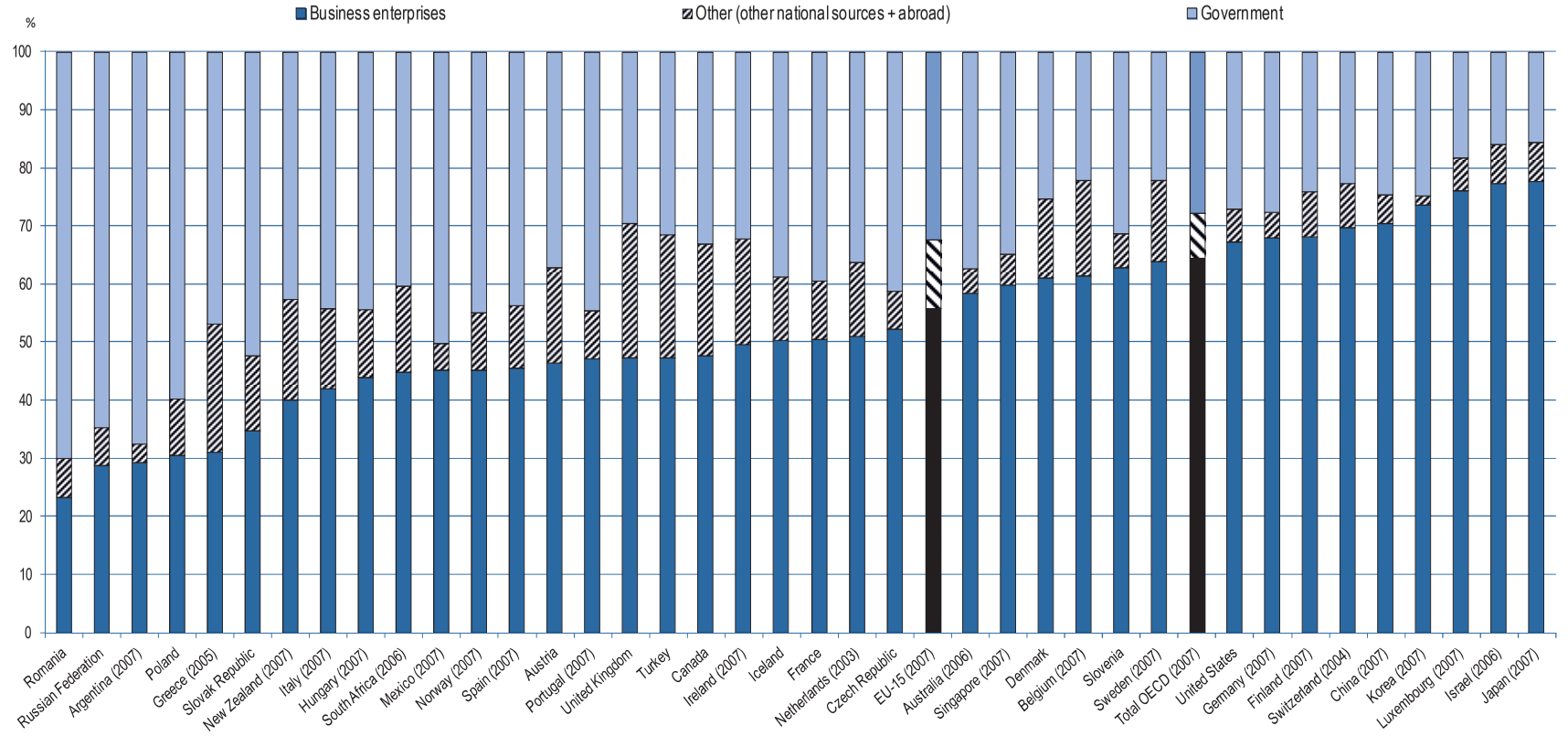
1998 and 2008, or nearest available years



Note: In Israel, defence R&D is not covered and humanities and law are only partially covered in the higher education sector. Owing to the lack of a comprehensive business register for South Africa, R&D expenditure may be underestimated by 10-15%.

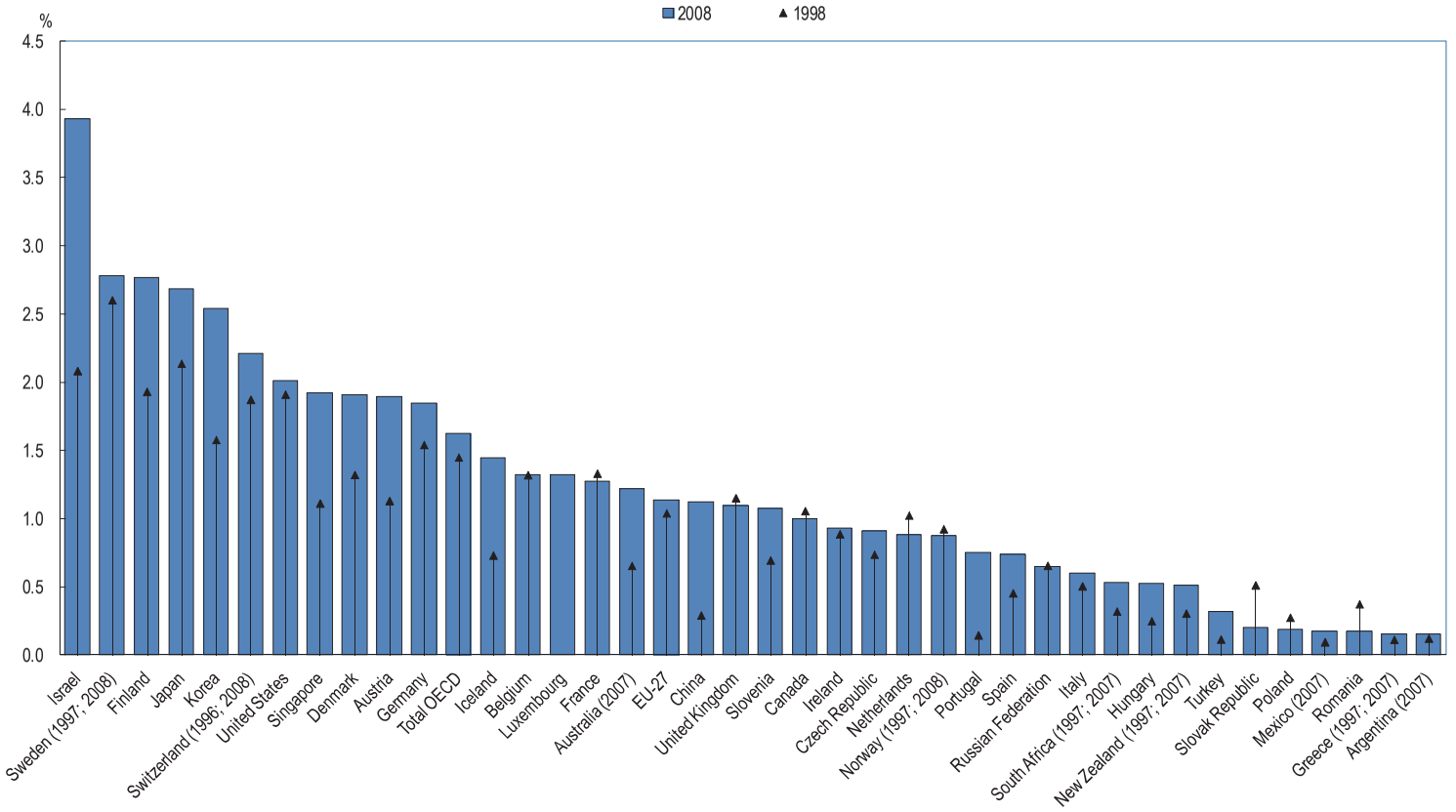
Source: OECD (2010, p. 25.), *http://dx.doi.org/10.1787/888932332626*.

Figure 2.3. R&D expenditure by source of financing, as a percentage of national total, 2008 or nearest available year



Source: OECD (2010, p. 31), *http://dx.doi.org/10.1787/888932332721*.

Figure 2.4. BERD intensity, selected countries, 1998 and 2008, or nearest available years



Note*:* In the Russian Federation, much R&D is traditionally performed by public enterprises, which are classified in the business enterprise sector. Owing to the lack of a comprehensive business register for South Africa, R&D expenditure may be underestimated by 10-15%.

Source: OECD (2010, p. 27), *http://dx.doi.org/10.1787/888932332664*.

Yet, while business enterprise expenditure on R&D (BERD) as a percentage of GDP (BERD intensity) is just below the EU average it still lags far behind the levels of leading countries (Figure 2.4). As in other countries, the bulk of R&D in Slovenia is performed by a rather small number of firms, led by two producers of pharmaceutical generics, one a domestically owned company, the other a subsidiary of a multinational enterprise (MNE). The business enterprise sector finances around 89% of its intramural R&D, while 8% comes from government and 3% from abroad (Eurostat, 2010, p. 49). Slovenia's industry can be described as a rather robust R&D performer when compared to other central and eastern European countries (Table 2.3).

Between 2008 and 2009, the Slovenian government "has significantly increased public sector expenditures as one of the measures to combat the economic crisis. This has raised the share of the public sector in R&D spending by 0.27 p.p. compared to 2008" (Bucar *et al*., 2010, p. 33). This seems to be a reaction to the business sector's difficulties for maintaining its level of R&D expenditure in 2009; However, the private sector's share of GERD is still the highest of the 12 new EU member states.

As noted, the public sector's and industry's overall shares of GERD are in the European mainstream and close to the EU goal of two-thirds of GERD from private sources. Business funding of R&D in higher education institutions (HEIs) and public research organisations (PROs) represents about 6.5% of overall private expenditure (Table 2.2). This constituted around 13% of overall PRO research budgets and about 10% of university research budgets in 2008 (Bucar *et al.*, 2010, pp. 50 and 52). Table 2.2 also shows that the government's R&D budget includes a rather small share to HEIs and thus accounts for a small share of higher education R&D performance.

Table 2.2. R&D expenditure (GERD) by sector of funding and performance, 2008

	Funding sector				
Performing sector	Government	Business	Abroad	Higher education sector	Share in GERD
Higher education sector	33 %	2.1 %	27 %	100 %	13.5 %
Government research institutes	55.5 %	4.4 %	31.5 %	0 %	22 %
Business enterprises	11.5 %	93.5 %	41.5 %	0%	64.5 %
Total	100% (EUR 193 million)	100% (EUR 387 million)	100% (EUR 34.5 million)	100% (EUR 1.8 million)	100% (EUR 616.9 million)
Share in GERD	31 %	63 %	5.5 %	0.3%	100.0%

Source: Statistical Office of the Republic of Slovenia (2010), from Bucar *et al.* (2010).

Taken together, the financial engagement of industry in university research is relatively high by international standards. Germany records an industry share of 12.2%, the Netherlands 10%, Finland 8.6% and Switzerland 8.3%, while Sweden (4.5%), Norway (4%) and Denmark (2.3%) show much less industry involvement (Danish Ministry for Science, Technology and Innovation, 2009, p. 59; data as of 2006). The comparability of data across countries is limited, however, as they are affected by cultural specificities as well as differences in the relative importance of HEIs and PROs in the public research portfolio. For Slovenia this means two things. First, financing of HEIs by industry seems quite high, despite concerns expressed by various stakeholders. Second,

the large PRO sector could benefit more from private funding. In this context it would appear appropriate to discuss the PROs' "uniform" mission , *i.e.* the fact that nearly all PROs in Slovenia are to perform basic research as well as contract research (on this point, see the section on PROs in Chapter 3).

Table 2.3. Composition of R&D by performance sectors, % of GDP

	2000	2004	2005	2006	2007	2008	2009
BERD	0.79	0.95	0.84	0.94	0.87	1.07	1.20
GOVERD	0.37	0.28	0.35	0.38	0.35	0.36	0.39
HERD	0.23	0.19	0.24	0.24	0.23	0.22	0.27
Non-profit	0.02	0.004	0.003	0.003	0.002	0.002	0.002

Source: OECD (2011).

Table 2.3 shows the change over time in the composition of GERD by sector of performance. What is most striking is the high degree of stability. The evolution of these shares – as well as the evolution of total R&D – has been remarkably smooth compared to other central and eastern European countries. The exception is the share of business-sector R&D, which fluctuated around 0.9% of GDP in the immediate pre-crisis period and rose in 2008 and 2009, a sign that the business sector did not reduce R&D activity strongly in reaction to the crisis. However, there are signs that the Slovenian government, leveraged by European structural funds, has directed more public funding into programmes that support industrial R&D – from SID Bank and Slovene Enterprise Fund (SEF) instruments to Slovenian Technology Fund (TIA) programmes.A further rise in public funding of R&D to 1% of all public expenditures by 2012 (currently around 0.75%) and to 1.2% by 2020 is envisaged (*Official Gazette of the Republic of Slovenia*, 2011, p. 3). Furthermore, GERD is expected to reach 3% of GDP in 2020 (Republic of Slovenia, 2011).

The percentage of GERD financed by sources from abroad varies strongly across European and OECD countries more generally. This is due to differences in the structural features of national innovation systems and to differences in their openness. In EU member countries funding from abroad generally consists of a (usually smaller) share of EU funding and a (typically larger) share of funding from multinational enterprises. Slovenia, which has fared well in attracting EU funding, had an overall share of around 6% of GERD financed from foreign large firms in 2009 and earlier years (OECD, 2011). This is rather low for a small open economy and may be due to the ownership structure of industry and perhaps a preference for in-house solutions.

Public and private funds can be used for different kinds of R&D activities. In a sample of 20 European countries Slovenia ranked last in 2006 with a share of just 12% of GERD devoted to "basic research". Hungary, Estonia and the Czech Republic allocate twice as much, while Ireland and Switzerland also spend much more of GERD on basic research. At 20%, Slovenia also ranked lowest with respect to the share of "experimental development"; most other countries record shares of 30-45%. Consequently, more than two-thirds of total R&D expenditure in Slovenia is for "applied research" (Eurostat, 2010, p. 51). This pattern cannot be explained simply by the share of industrial R&D. But it is consistent with the uniform "catch-all" mission of the PRO sector mentioned above. To a certain extent such an approach is also encountered at the universities.

Table 2.4 gives the share of BERD performed in selected industries over 2000-08. While the electronics industry's share declined from 14.8% to 8.5% in 2008, the pharmaceutical industry saw an increase from 25.7% to 34.7%. The instruments industry recorded a slow decline with minor fluctuations during this period from 5.1% in 2000 to 4.4% in 2008. The services industries, however, saw a steep decline from 19.3% in 2000 to a record low of 5.4% in 2003, and have since recovered to a share of 13% in business expenditures for R&D in 2008, still well below the 2000 level.

Table 2.4. Percentage of Slovenia's business R&D performed in selected industries

	2000	2001	2002	2003	2004	2005	2006	2007	2008
Electronics industry	14.8	15.9	12.2	16.1	13.1	14.4	11.4	10.2	8.5
Pharmaceuticals industry	25.7	28.0	30.8	39.7	41.2	31.2	36.3	37.2	34.7
Instruments industry	5.1	5.1	6.3	5.5	4.7	5.2	4.2	4.8	4.4
Service industries	19.3	15.1	13.7	5.4	6.3	8.2	8.8	9.2	13.0

Source: OECD (2011).

The pharmaceuticals industry not only accounts for the highest share of BERD, it also has the highest export market share: it grew from 32% in 2000 to 45% in 2009 (Table 2.5).[2] It also had a significant increase in the export/import ratio from 1.58 in 2000 (USD 397.5 million in exports and USD 251.5 million in imports) to 2.13 in 2009 (USD 2 109.9 million in exports and USD 989.5 million in imports). Both the electronics and instruments industry instead recorded a decline in their share of BERD and a stagnating export market share.

Table 2.5. Export market share in selected industries, 2000-09

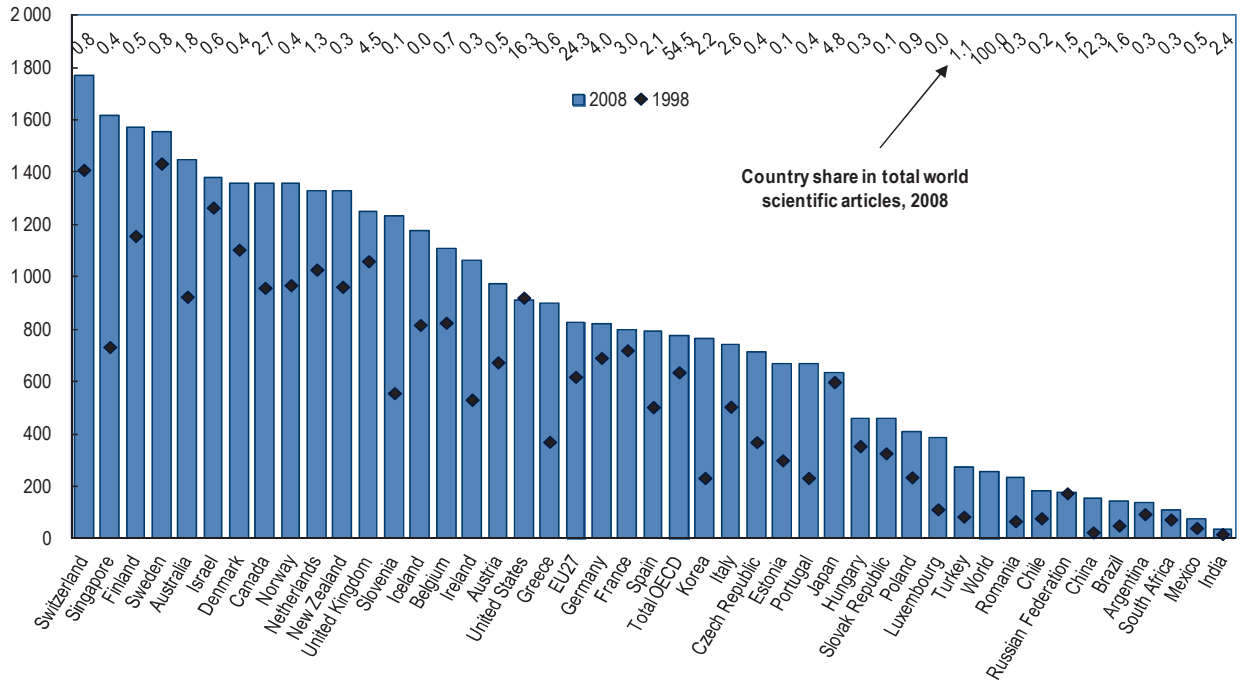
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Electronics industry	0.04	0.05	0.05	0.05	0.04	0.03	0.03	0.03	0.04	0.04
Pharmaceuticals industry	0.32	0.32	0.34	0.42	0.41	0.39	0.44	0.49	0.51	0.45
Instruments industry	0.11	0.11	0.12	0.12	0.12	0.12	0.12	0.12	0.13	0.12

Source: OECD (2011).

2.2. Innovation outputs

Slovenia's innovation output is varied. Scientific output, as measured by the number of scientific articles per million population, is high by international standards, reflecting a solid science base. It has grown rapidly since the 1990s (Figure 2.5), owing, among other things, to the emphasis on bibliometric indicators for the evaluation of research. The average annual growth rate of publications from 2002 to 2006 was 8%. The relative impact factor of Slovenian scientific publication has risen even faster over the last years, at an average annual rate of 16% in most disciplines. Natural sciences account for most of the papers with higher citation rates. Overall impact, however, still considerably lags the OECD and EU27 averages (Bucar *et al.*, 2010, p. 39). The world share for papers is 0.19% and for citations 0.1% (FWF, 2011, p. 76).

Figure 2.5. Scientific articles per million population, 1998 and 2008

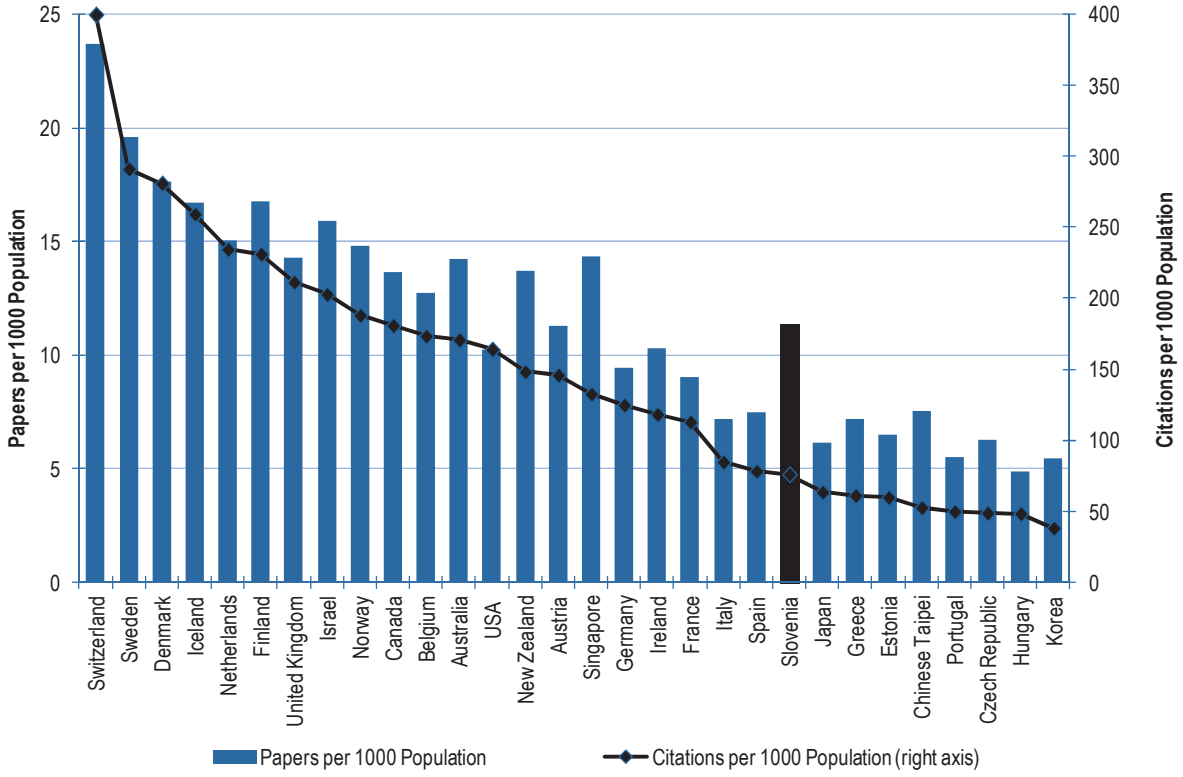


Note: "Scientific articles" are sourced from journals and conference proceedings and include: articles, reviews, conference papers, conference reviews and notes. Calculations based on the address of the institution to which authors belong, and fractional counts. For Brazil, Chile, Estonia and India, population data come from the International Monetary Fund, World Economic Outlook Database, April 2010.

Source: OECD (2010, p 50), *http://dx.doi.org/10.1787/888932332854.*

A comparison of bibliometric data for 2000-10 shows additional interesting features (FWF, 2011, p. 76). First, Slovenia ranks 22nd among the world's top 30 countries in terms of citations normalised by population (Figure 2.6) and leads among new EU member states (Estonia ranks 25th, the Czech Republic 28th and Hungary 29th). At 76.2 citations per 1 000 population, however, Slovenia still has considerable scope for catching up: Switzerland leads the global list with an impact ratio five times higher (399.8), followed by Sweden (291). The potentially encouraging message relates to country size: the next four top positions behind Switzerland and Sweden are held by relatively small countries: Denmark, Iceland, the Netherlands and Finland, while Israel, Norway, Belgium, New Zealand and Austria are among the top 15. This suggests that ambitions can be set high as there appears to be no small country disadvantage. However, to improve Slovenia's position will require a long-term effort and greater dynamism. Slovenia's two-year citation growth is 13.1%, but the range for all top 30 countries is 11-15%.

Figure 2.6. Intensity of scientific output and impact, selected countries, 2000-10

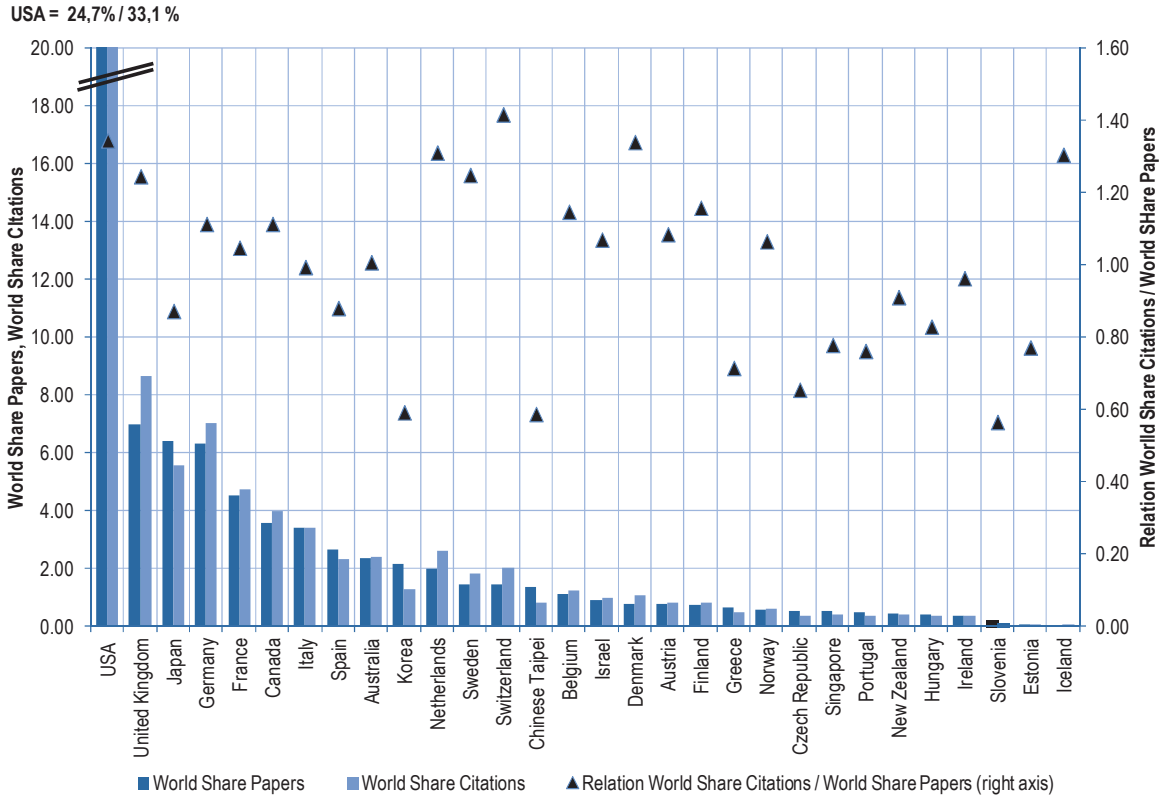


Source: BMWF, BMVIT, BMWFJ (2011), Austrian Research and Technology Report 2011, based on ISI, calculations by Joanneum Research.

There is undoubtedly room for improvement in citations: at 6.7 citations per paper Slovenia ranks last among the top 30 countries (Table 2.6), an indication that its scientific output is not very visible in the international scientific community. Moreover, in terms of the relation of world share of papers to world share of citations (Figure 2.7) Slovenia stands last (0.56), slightly behind other new EU member states such as the Czech Republic (0.65) and Estonia (0.77). The clear leader in this ranking is once again Switzerland (1.42), followed by the United States (1.34), Denmark (1.34), the Netherlands (1.31), Sweden (1.25) and the United Kingdom (1.24) all of them with a ratio well above 1.

This issue has received more government attention in the new RISS strategy (*Official Gazette of the Republic of Slovenia*, 2011, p. 8; MHEST, 2011). The impact factors – IF 3.09 and 22nd position in the EU at 61% of the EU average – are considered relatively poor. However, there seems to be a thin layer of top scientists who account for a relatively high number of adequately to highly cited publications.

Figure 2.7. World share of scientific papers and citations, selected countries



Source: BMWF, BMVIT, BMWFJ (2011), *Austrian Science and Technology Report 2011*, based on ISI, calculations by Joanneum Research.

Nearly all of the top 30 countries boast at least some ISI highly cited researchers (HCR). While the absolute number of highly cited researchers is highest for the United States (4 143), Switzerland leads in terms of HCR per million population with 15.5, while the United States has 14.1. Switzerland and the United States clearly lead this ranking, followed by Israel, Sweden, the Netherlands, Canada, Australia and Denmark, all of which have more than five but fewer than eight HCR per million population. Among the top 30 countries only four currently have no HCR: the Czech Republic, Estonia, Iceland and Slovenia. Among the new EU member states Hungary is a positive outlier with seven HCR. For Slovenia this can be worrying, as the existence of highly cited researchers is not correlated to country size. There is some hope that the quality-enhancing policies and instruments of the Ministry of Higher Education, Science and Technology (MHEST) and the Slovenian Research Agency (SRA) will contribute to a gradual improvement over time. However it can be argued that there is some correlation between Slovenia's current position and both the organisational set-up of the PRO and HEI sectors and the characteristics of some incentives provided by funding (for details, see Sections 3.2, 3.3 and 4.2).

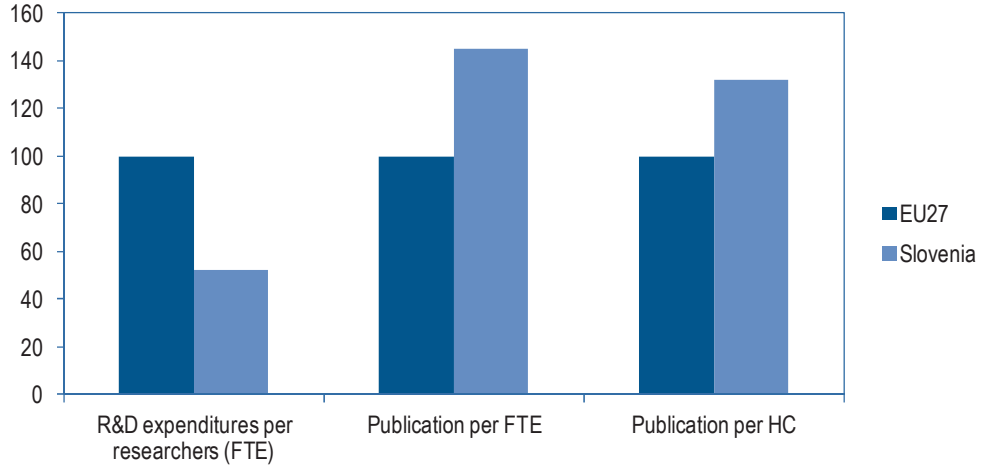
Table 2.6. Bibliometric data of the top 30 countries (ranked by citation per 1 000 population), 2000-10

Country	Papers (thousands)	Citations (thousands)	Population (millions) (2000-09)	World share papers %	World share citations %	Citation per paper	Papers per 1 000 population	Citations per 1 000 population	2 yr citation growth %	ISI HCR	HCR per million population
CHE	176	2 970	7	1.4	2.0	16.9	23.7	399.8	11.5	115	15.5
SWE	177	2 632	9	1.4	1.8	14.9	19.6	291.0	11.3	65	7.2
DNK	95	1 521	5	0.8	1.0	15.9	17.6	280.8	11.7	31	5.7
ISL	5	77	0	0.0	0.1	15.5	16.7	259.2	13.3	0	0.0
NLD	244	3 813	16	2.0	2.6	15.6	15.0	234.4	11.8	105	6.5
FIN	88	1 213	5	0.7	0.8	13.8	16.8	231.2	11.4	20	3.8
GBR	853	12 648	60	7.0	8.7	14.8	14.3	211.4	11.4	115	1.9
ISR	110	1 407	7	0.9	1.0	12.7	15.9	202.7	11.3	50	7.2
NOR	69	870	5	0.6	0.6	12.7	14.8	188.0	12.2	14	3.0
CAN	439	5 814	32	3.6	4.0	13.2	13.7	180.9	11.7	196	6.1
BEL	133	1 817	10	1.1	1.2	13.7	12.7	173.4	12.1	39	3.7
AUS	290	3 482	20	2.4	2.4	12.0	14.2	170.8	12.1	122	6.0
USA	3 018	48 299	295	24.6	33.1	16.0	10.2	164.0	11.1	4 143	14.1
NZL	56	607	4	0.5	0.4	10.8	13.7	148.3	12.0	20	4.9
AUT	93	1 198	8	0.8	0.8	12.9	11.3	146.0	11.9	20	2.4
SGP	62	570	4	0.5	0.4	9.3	14.3	132.6	14.7	4	0.9
DEU	776	10 277	82	6.3	7.0	13.2	9.4	124.9	11.4	262	3.2
IRL	43	488	4	0.3	0.3	11.5	10.3	118.3	12.5	8	1.9
FRA	551	6 875	61	4.5	4.7	12.5	9.1	112.9	11.3	166	2.7
ITA	417	4 930	58	3.4	3.4	11.8	7.2	84.8	11.8	85	1.5
ESP	322	3 372	43	2.6	2.3	10.5	7.5	78.3	12.5	24	0.6
SVN	**23**	**152**	**2**	**0.2**	**0.1**	**6.7**	**11.3**	**76.2**	**13.1**	**0**	**0.0**
JPN	781	8 110	128	6.4	5.6	10.4	6.1	63.6	11.0	263	2.1
GRC	80	678	11	0.7	0.5	8.5	7.2	61.1	13.5	6	0.5
EST	8	78	1	0.1	0.1	9.2	6.5	59.8	12.7	0	0.0
TWN	166	1 159	22	1.4	0.8	7.0	7.5	52.7	13.5	19	0.9
PRT	58	523	10	0.5	0.4	9.1	5.5	49.9	14.0	1	0.1
CZE	65	503	10	0.5	0.3	7.8	6.3	48.9	13.0	0	0.0
HUN	50	489	10	0.4	0.3	9.9	4.9	48.4	12.1	7	0.7
KOR	261	1 835	48	2.1	1.3	7.0	0.0	0.0	14.1	-	-

Source: FWF, 2010, p. 76 and ISI database 7/2011.

According to Bucar *et al.* (2010) Slovenia spends comparatively little per researcher but researchers seem to be more productive than the EU average (Figure 2.8).

Figure 2.8. Selected R&D output indicators



Source: Eurostat database, MHEST internal data; from Bucar *et al*. (2010).

In terms of other measures of innovation output, the picture is also somewhat mixed. The number of high-technology firms in manufacturing and services is relatively small, falling short of levels in the Czech Republic and Hungary. High-technology and service exports have remained low in international comparison (Bucar *et al.*, 2010, p. 105; see also Chapter 1). Patent data show a pattern that lends itself to multiple interpretations: Slovenia currently lags behind the EU average in patent applications per million population by a significant margin, but performs better than almost any other new EU member state. The number of European Patent Office (EPO) applications has been rising steeply (Eurostat, 2010, p. 185). Table 2.7 presents the number of European patent applications filed with the EPO per million population for Slovenia and the EU27 average. In 2000 Slovenian inventors filed only one-seventh of the EU27 average number of patent applications, but in 2009 it files almost half of the EU27 average, an impressive growth in the application rate.

Table 2.7. European patent applications filed with EPO per million population, 2001-10

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
EU27	102.8	101.6	110.4	114.7	118.5	121.4	125.2	130.9	123.5	132.6
Slovenia	14.6	15.5	23.0	27.0	43.5	44.3	57.0	63.8	58.3	65.9

Source: EPO, *www.epo.org/about-us/statistics/patent-applications.html.*

Still, while the number of Slovenian patent applications more than quadrupled from 2000 to 2009 (the EU27 average recorded only a 30% increase), the number of patents per million inhabitants granted by the EPO only doubled to one-third of the EU27 average in 2009 (Table 2.8). Thus, this pattern resembles the one for scientific publications: while absolute numbers increase, acceptance rates (citations, patents granted) still lag behind.

Table 2.8. European patents granted by the EPO per million population, 2001-10

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
EU27	31.1	43.3	53.6	52.1	46.6	53.1	45.3	51.5	44.3	48.5
Slovenia	8.0	8.0	10.0	12.0	12.0	10.5	8.4	16.3	13.7	16.1

Source: EPO, *www.epo.org/about-us/statistics/granted-patents.html*.

EPO statistics list 35 technological subfields in chemistry, electrical engineering, instruments, mechanical engineering and other fields, but up to 64.1% of all Slovenian patent applications filed with the EPO in 2008 were in just two chemistry subfields, namely "organic fine chemistry" and "pharmaceuticals" (Table 2.9).

Table 2.9. European patent applications filed with the EPO 2001-10, total, organic fine chemistry and pharmaceuticals

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total
Total	29	31	46	54	86	89	115	128	118	117	**813**
Organic fine chemistry and pharmaceuticals	9	2	7	12	38	53	60	82	69	56	**388**
Share	31.0%	6.5%	15.2%	22.2%	44.2%	59.6%	52.2%	64.1%	58.5%	47.9%	**47.7%**

Source: EPO, *www.epo.org/about-us/statistics/patent-applications.html*.

During 2001-10 Slovenia was granted patents in 35 different technological fields (EPO online). The leading fields are pharmaceuticals (31), organic fine chemistry (25), civil engineering (21) and electrical machinery, apparatus and energy (20). Next are biotechnology (15), other consumer goods (14), machine tools (12), mechanical elements (10) and medical technology (10). Technical fields in which Slovenia did not have a single EPO patent during 2001-10 are food chemistry, macromolecular chemistry and polymers, micro-structural and nanotechnology, IT methods for management, semi-conductors and telecommunications. One-quarter of all EPO patents granted to Slovenia are in organic fine chemistry and pharmaceuticals (Table 2.10).

Table 2.10. European patents granted to Slovenia by the EPO. 2001-10, total, organic fine chemistry and pharmaceuticals

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total
Total	16	16	20	24	24	21	17	33	28	33	**232**
Organic fine chemistry and pharmaceuticals	1	1	5	6	6	3	4	11	6	13	**56**
Share	6.3%	6.3%	25.0%	25.0%	25.0%	14.3%	23.5%	33.3%	21.4%	39.4%	**24.1%**

Source: EPO, *www.epo.org/about-us/statistics/granted-patents.html*.

EPO data for 2005 show an extremely low share of high-technology patent applications from Slovenia. The EU average share of high-technology patent applications in total EPO patent applications is 18.7%. The Czech Republic (15.9%) and Hungary (17.6%) come close to this level, but Slovenia lags far behind at 4.5%, with extremely low absolute numbers (Eurostat, 2010, p. 195). As regards triadic patent families, the country's poor record is shared with many other countries, including all the other new, and some longstanding, EU members (OECD, 2011).

The PRO sector is the most important source for patent applications, while industry and universities show a less impressive record. The application rates of the newly started centres of excellence are encouraging (Table 2.11).

The recent increase in business sector R&D may be a harbinger of further improvements.[3] Several recent initiatives by PROs to enlarge their technology transfer offices (TTOs) and the highly entrepreneurial start-up ethos that permeates the Ljubljana Technology Park, for example, are indicative of awareness and commitment to increased levels of technological innovation. However it will take time for a small country with an established industry structure to change patterns.

Trademarks and design form another, softer category of innovation-relevant intellectual property. Here Slovenia shows a strong catch-up performance, albeit from a low base. According to the Innovation Union Scoreboard (European Commission, 2011, p. 51), the number of Community designs is around half the EU average and trademarks around 70%. Such a catch-up process is typical of the new EU member states.

Table 2.11. Patents and patent applications according to sector of applicant, 2008 and 2009

	2008		2009	
	Patents	Patent applications	Patents	Patent applications
Business sector R&D	80	78	77	73
HEIs	73	59	87	98
PROs	96	33	61	132
Centres of excellence	26	7	7	41
Total	249	170	225	303

Source: Bucar *et al.* (2010), based on data IZUM-SICRIS (2010) data.

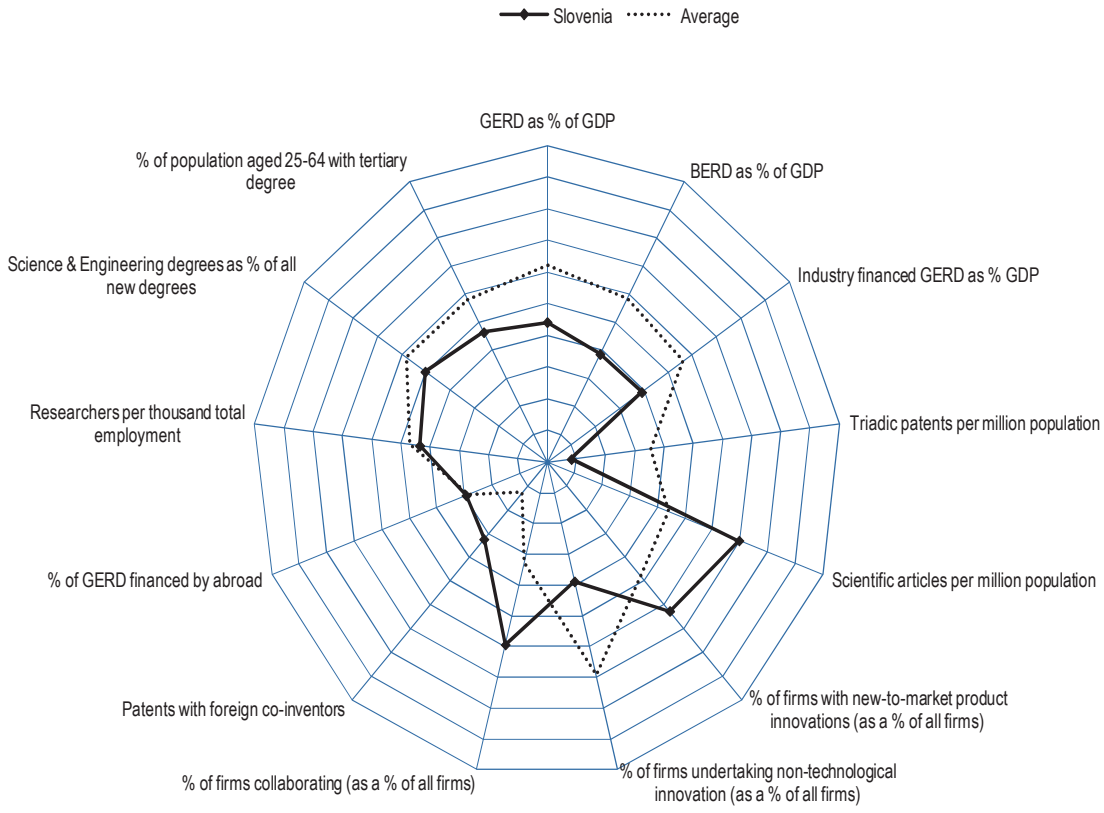
2.3. International benchmarking of the system

OECD benchmarking

Each OECD country displays a specific pattern of strengths and weaknesses as regards innovation inputs and outputs. Such patterns are reflections of historical trajectories and past decisions. Change takes time and requires customised approaches, as policy mixes based on uncritical imports of "best practices" are unlikely to yield satisfactory results. Yet it is necessary to compare, to build on strengths and to try to eliminate weaknesses. Industrialised countries in Europe find a solid basis for such benchmarking in OECD and EU comparisons.

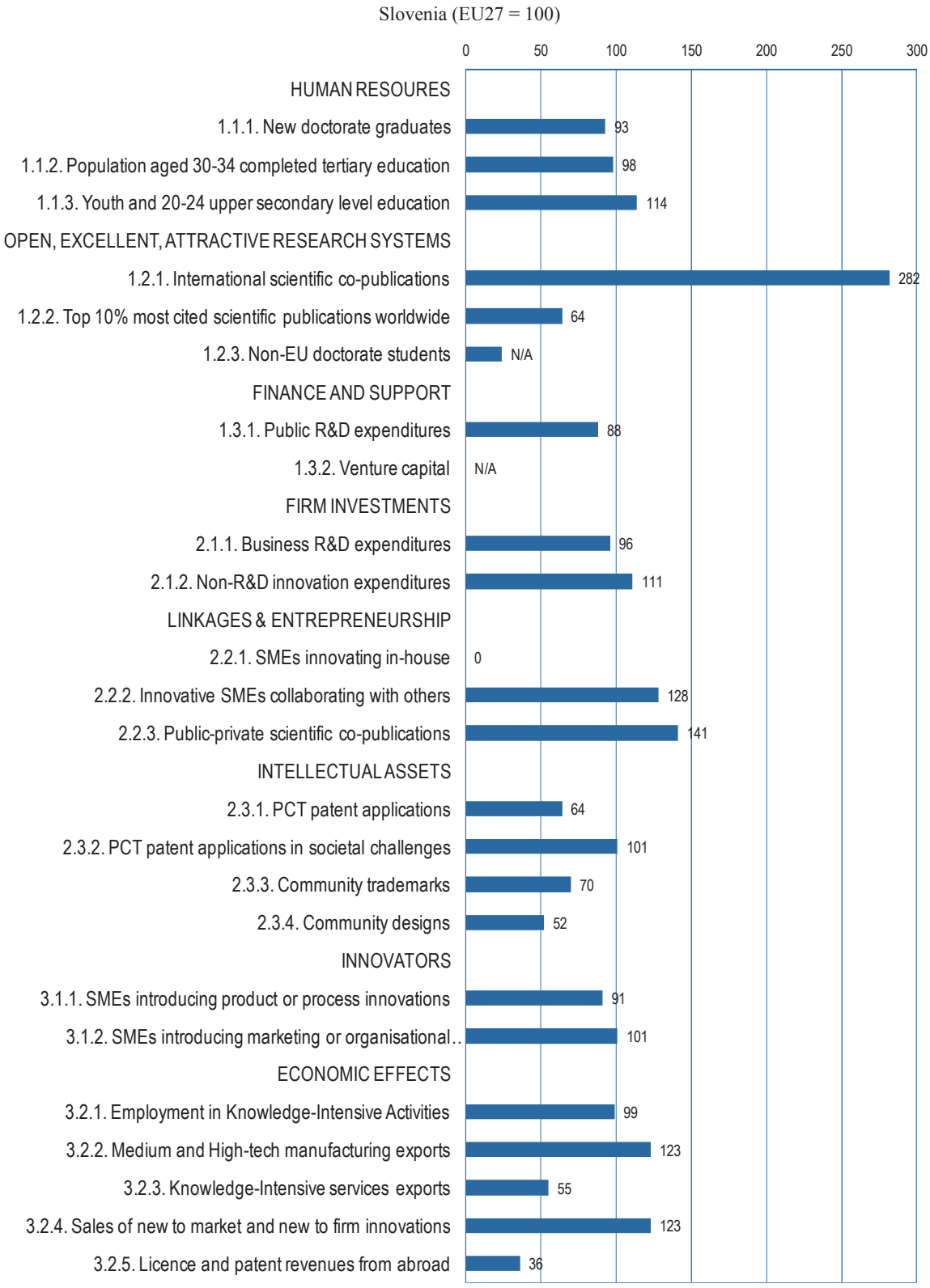
Figure 2.9 benchmarks Slovenia against the OECD average for a set of indicators (OECD, 2010, p. 219). The comparison shows Slovenia as performing above average in several dimensions, notably in scientific output on a per capita basis, but also in aspects of business innovation and co-operation. As a small open country Slovenia can benefit from collaboration, *e.g.* in creation of intellectual property. However, in other indicators Slovenia ranks below the OECD average. Relative weaknesses relate to aspects of the human resource base and R&D expenditure and patents. Slovenia ranks above the average in only in four of the thirteen indicators.

Figure 2.9. Science and innovation profile of Slovenia, input and output dimensions



Source: OECD (2010, p. 219), *http://dx.doi.org/10.1787/888932334906*.

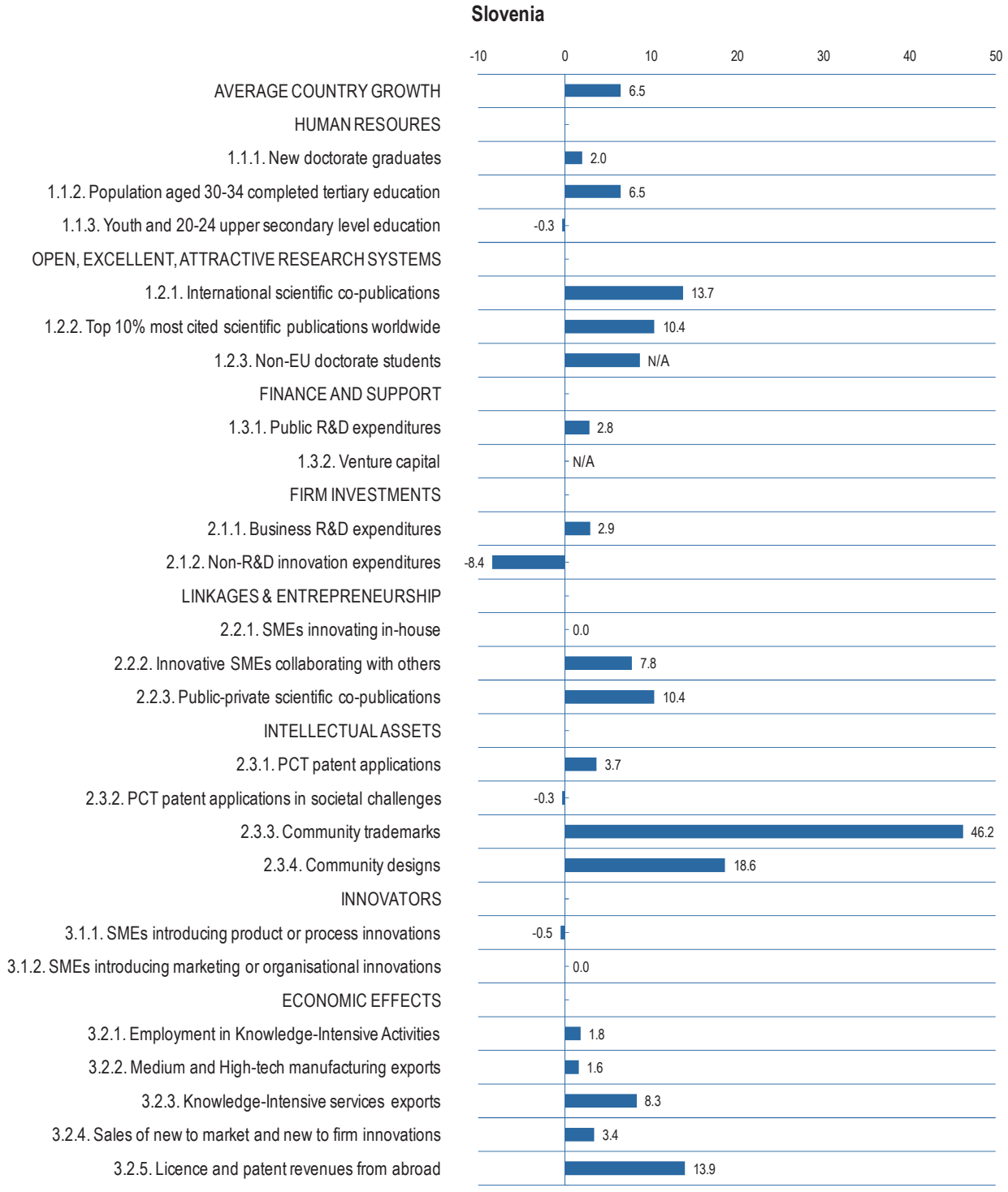
Figure 2.10. Innovation Union Scoreboard 2010: Slovenia's indicator values relative to the EU27



Source: European Commission (2011).

Figure 2.11. Innovation Union Scoreboard 2010

Slovenian indicator values, annual growth per indicator and average annual growth



Source: European Commission (2011).

Innovation Union Scoreboard benchmarking

Overall, Slovenia is described as an "innovation follower", *i.e.* as a country whose performance is close to that of the EU27 average in the 2010 Innovation Union Scoreboard (IUS) (European Commission, 2011). Among the group of "innovation followers" (Austria, Belgium, Estonia, France, Ireland, Luxembourg, the Netherlands, Slovenia), Estonia and Slovenia are the growth leaders (European Commission, 2011, p. 14). The IUS captures 25 different indicators of three main types (enablers, firm activities and outputs) that cover eight dimensions of innovation (human resources; open, excellent and attractive research systems; finance and support; firm investments; linkages and entrepreneurship; intellectual assets; innovators; economic effects).

Figure 2.10 illustrates Slovenian indicator values relative to the EU27. These indicator values translate into the following rankings (European Commission, 2011, p. 16): in enabler indicators, for human resources Slovenia (rank 11) is above the EU27 average (set to 100) but for open, excellent and attractive research systems (rank 14) and finance and support (rank 12) it ranks below the EU27 average. In firm activities indicators, Slovenia (rank 11) is above the EU27 average in firm investments and in linkages and entrepreneurship (rank 11), but for intellectual assets (rank 14) it is below the EU27 average. In the outputs indicator category, Slovenia ranks below the EU27 average for both the innovators (rank 15) and economic effects (rank 14) dimensions. Tables 2.10 and 2.11 show the indicator values for Slovenia relative to the EU27 in terms of current standing and of average annual growth per indicator and average country growth (European Commission, 2011, p. 51).

In terms of the 25 indicators used for the Innovation Union Scoreboard (Figure 2.10), Slovenia has relative strengths in human resources, with young people aged 20-24 with upper secondary level education above the EU27 average of 100 (114), but the number of new doctorates (93) and the population aged 30-34 that completed tertiary education (98) is slightly below the EU27average. However, as shown in Figure 2.11, there is slow growth in new doctorates (2%) and faster growth in the population aged 30-34 having completed tertiary education (6.5%). This shows that Slovenia is converging to the EU27 average in the human resources dimension. While international scientific co-publications are far above the EU27 average (282), the number of top 10% most cited scientific publications worldwide (64) and non-EU doctoral students (24) are significantly below the EU27 averages (Figure 2.10). All three indicators show rather good growth rates: international scientific publications (13.7%), top 10% most cited scientific publications worldwide (10.4%), and non-EU doctoral students (8.7%) (Figure 2.11).

While the above-mentioned *enabler* indicators show good performance overall, the *firm activities* indicators show relative weakness, with a significant decline in non-R&D innovation expenditures (-8.4%). While business R&D expenditure (96), Patent Cooperation Treaty (PCT) patent applications (64), Community trademarks (70), and Community designs (52) are below the EU27 average, Community trademarks (46.2%) and Community designs (18.6%) show high growth. However, slow growth of business R&D expenditure (2.8%) and PCT patent applications (3.7%) indicate that it may take Slovenia a long time to catch up.

The *output* indicators show a mixed picture of Slovenian innovation. While medium and high-technology manufacturing exports (123) and sales of new-to-market and new-to-firm innovations (123) are above the EU27 average, knowledge-intensive service exports (55) and licence and patent revenues from abroad (36) are significantly below the EU27 average. In this set of indicators the highest growth rate is in licence and patent

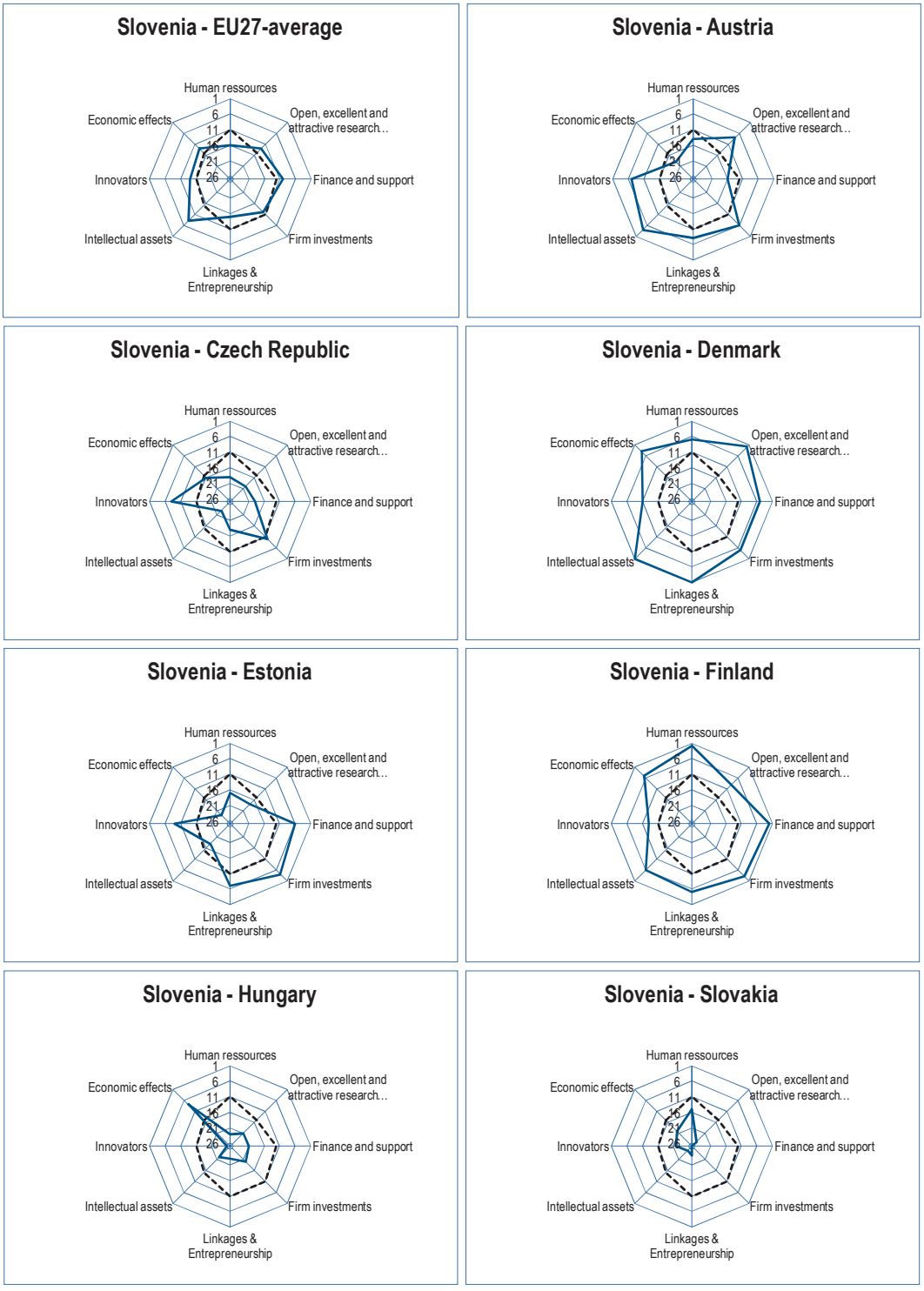
revenues from abroad (13.9%). SMEs currently do not show any increase in innovation activities, either for introducing product or process innovations (-0.5%) or for introducing marketing or organisational innovations (0%).

Figure 2.12 shows bilateral comparisons of Slovenia with selected smaller EU countries and the EU27 average in the eight IUS indicator dimensions. Slovenia already is above the EU27 average in three dimensions (human resources, linkages an entrepreneurship, firm investments) and close to the EU27 average in four more (open, excellent and attractive research systems, finance and support, innovators, economic effects). The strongest catch-up effort is required in the intellectual assets dimension. Slovenia clearly outperforms other new EU members such as the Czech Republic, the Slovak Republic and Hungary and seems to have much more balanced strength in the eight indicator dimensions than Estonia (as mentioned, Slovenia and Estonia are the "growth leaders" among the innovation followers). This more balanced strength is also visible at a higher level in innovation leaders such as Denmark and Finland, while another innovation follower, Austria, is below Slovenia in three dimensions (economic effects, human resources, finance and support) and shows a more unbalanced distribution across the eight dimensions.

Overall – and recognising a number of impressive examples and its performance among former transition or new EU members – Slovenia does not perform particularly well in terms of new firm formation or transfer of technology. Early entrepreneurial activity in Slovenia cannot be described as dynamic, and the same applies for the SME sector more generally. Concerns have been raised about the economy's ability to convert findings from research into technological innovations. Results from past innovation surveys show little change in innovation activity in the manufacturing sector and only a gradual increase in services. As in other countries, the innovation policies of Slovenia are biased towards the promotion of technological innovations relevant to the manufacturing sector (Stare and Bucar, 2009). Insufficient attention is given to promoting innovations in the services sector, in spite of the increasing share of services in GDP.

As discussed in more detail in other parts of this review, these shortcomings in Slovenia's innovation system are due to several mutually reinforcing factors. These include weak incentives for academic faculty who receive national research funds to consider the potential relevance of their work to business sector users and the apparent lack of interest in cutting-edge production processes and practices among many SMEs, the dominant type firm in terms of output and employment. A lack of innovativeness threatens firms' competitive position, especially in internationally contested markets. In past innovation surveys companies cite a lack of financial resources as the most common reason for not engaging in innovation activity. A consequence is what might be described as a "low-level equilibrium", with some larger companies reported still to be suffering from former buy-outs and low capitalisation. Another partial explanation for the observed weaknesses in innovation output, noted above, is the small inflow of foreign direct investment (FDI) when compared to Slovenia's strong integration into international goods markets and the FDI to other central and eastern European countries. Slovenia's potential for receiving best-practice technology through inward FDI is not fully realised.

Figure 2.12. Bilateral comparison of Slovenia with selected EU countries in the eight IUS-indicator dimensions



Note: Slovenia dashed line, other country solid line.

Source: European Commission (2011).

Recognition of the need to address these shortcomings permeates recent national policy documents. Indeed, the proposals in these plans – to build on complementary initiatives by universities and PROs to expand, rationalise and professionalise their technology transfer capabilities, especially in the areas of patents, licences and start-up firms – are intended to spur and redirect activities towards such a path. Slovenia has a strong focus on building an effective national innovation system (NIS) and has also adopted many best practices from other countries.

Notes

1. R&D was an important activity in a number of Slovenian firms before 1991.
2. Export market shares are defined as the industry's total exports relative to total aggregate exports of the declaring countries in the STAN Bilateral Trade Database, which covers about 95% of world trade.
3. According to European Innovation Scoreboard 2010 data, Slovenia is making slow but continuous progress in its innovation performance, attaining membership in the group classified as *moderate innovators*. However, while activities and investments are significant, there is a significant gap between innovation outputs and inputs/enablers that reveals structural problems in the Slovenia innovation system.

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