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COUNTRY SNAPSHOT

Progress of Luxembourg towards ERA Roadmap

	Indicator	Performance				Growth					
		Name	Reference year	Score	Cluster	Lead/Gap (Δ %)	EU-28	Reference Period	CAGR	Trend (2005–2015)	Lead/Gap (Δ % pt)
Across Priorities	1 – Adjusted Research Excellence	2013	44.6	2	0	44.4	2010–2013	13.6%		7.2	6.4%
	2A – GBARD to transnatl coop (EUR/researcher)	2014	3,387	2	35	2,507	2010–2014	35.2%		27.4	7.8%
	2B – Roadmap for ESFRI projects	No national roadmap in place									
	3 – EURAXESS job ads per 1 000 researchers	2014	73.7	2	57	47.0	2012–2014	-26.0%		-33.8	7.8%
	4 – Share of women among Grade A HES	2014	16.5%	4	-30	23.5%	2007–2014	8.6%		5.3	3.4%
	5A – Research institute–private collaboration	2012	7.7%	3	6	7.3%	2008–2012	-12.0%		-15.5	3.5%
	5A – Higher education–private collaboration	2012	7.0%	3	-41	12.0%	2008–2012	-12.3%		-13.6	1.3%
	5B – Share of papers in Open Access (Total)	2014	61.0%	1	17	52.2%	Not computed				
	6 – Collab papers w/non-ERA per 1 000 researchers	2014	44.7	2	-12	50.7	2005–2014	13.8%		9.7	4.1%
Headline Composite	2016	56	2	12	50	Not computed					
Priority 1	Adjusted Research Excellence ^(c)	2013	44.6	2	0	44.4	2010–2013	13.6%		7.2	6.4%
	GBARD as share of GDP ^(c)	2014	0.719%	2	7	0.671%	2008–2014	8.3%		8.8	-0.5%
	European Innovation Scoreboard	2015	0.598	2	15	0.521	2008–2015	-0.8%		-1.5	0.7%
	GBARD as share of government expenditures	2014	1.70%	2	22	1.39%	2005–2014	12.5%		13.3	-0.8%
	R&D tax incentives as share of GBARD	2013	:			11.4%	Not computed				
	Share of GBARD allocated on project basis	2014	15.9%	Not computed			2009–2014	-3.8%		Not computed	
	Patent applications per 1 000 researchers	2013	23.0	2	-23	29.8	2005–2013	4.2%		5.4	-1.2%
	Researchers per 1 000 active population ^(c)	2014	9.88	2	33	7.40	2005–2014	-1%		-3.6	2.4%
	Publications per 1 000 researchers ^(c)	2014	326	3	-32	481	2005–2014	7.7%		6.0	1.6%
Priority 1 Composite	2016	49	2	-2	50	Not computed					
Priority 2	A – GBARD to transnatl coop (EUR/researcher) ^(c)	2014	3,387	2	35	2,507	2010–2014	35.2%		27.4	7.8%
	A – Collab papers w/ERA per 1 000 researchers ^(c)	2014	131.8	1	101	65.7	2005–2014	6.2%		2.5	3.6%
	A – Public-to-public partnerships (EUR/researcher) ^(c)	2014	2,836	1	454	512	2012–2014	29.4%		-12.7	42.1%
	A – Co-invention rate w/ERA partners ^(c)	2011–13 ^(R)	55.2%	1	324	13.0%	2007–2013 ^(R)	-0.8%		-0.3	-0.5%
	B – Roadmap for ESFRI projects	No national roadmap in place									
	B – Participation in developing ESFRI projects	2016	0.0%	3	-100	20.7%	Not computed				
	B – Participation in operational ESFRI landmarks ^(c)	2016	3.4%	3	-89	30.2%	Not computed				
Priority 2 Composite	2016	66	1	32	50	Not computed					

Country profile: Luxembourg

	Indicator	Performance					Growth				
		Name	Reference year	Score	Cluster	Lead/Gap (Δ %)	EU-28	Reference Period	CAGR	Trend (2005-2015)	Lead/Gap (Δ % pt)
Priority 3	EURAXESS job ads per 1 000 researchers ^(c)	2014	73.7	2	57	47.0	2012-2014	-26.0%		-33.8	7.8%
	Open, transparent, merit-based hiring process ^(c)	2012	63.4%	1	29	49.0%			<i>Not computed</i>		
	Share of doctoral students from EU countries ^(c)	2013	:			7.4%			<i>Not computed</i>		
	Priority 3 Composite	2016	79	1	25	63			<i>Not computed</i>		
Priority 4	Share of women among Grade A in HES ^(c)	2014	16.5%	4	-30	23.5%	2007-2014	8.6%		5.3	3.4%
	Gender dimension in research content ^(c)	2011-15 (R)	0.47	4	-52	0.97	2005-2015 (R)	1.5%		2.0	-0.5%
	Share of women among heads of HES institutions ^(c)	2014	0.0%	4	-100	20.1%			<i>Not computed</i>		
	Share of women researchers ^(c)	2013	27.3%	4	-18	33.2%	2005-2013	5.2%		4.4	0.8%
	Share of women among PhD graduates ^(c)	2012	50.9%	2	8	47.3%	2005-2012	0.0%		-1.2	1.2%
Priority 4 Composite	2016	30	4	-35	46			<i>Not computed</i>			
Priority 5	A - Research institute-private collaboration ^(c)	2012	7.7%	3	6	7.3%	2008-2012	-12.0%		-15.5	3.5%
	A - Higher education-private collaboration ^(c)	2012	7.0%	3	-41	12.0%	2008-2012	-12.3%		-13.6	1.3%
	A - Share of public R&D funded privately ^(c)	2013	2.3%	4	-72	8.1%	2009-2013	8.9%		8.0	0.9%
	A - Public-private collab papers per capita ^(c)	2014	40.0	2	18	33.9	2008-2014	0.3%		0.4	-0.1%
	B - Share of papers in Open Access (Total) ^(c)	2014	61.0%	1	17	52.2%			<i>Not computed</i>		
	B - Share of papers in Open Access (Green)	2014	57.2%	1	28	44.7%			<i>Not computed</i>		
	B - Share of papers in Open Access (Gold)	2014	20.6%	3	-2	21.0%			<i>Not computed</i>		
B - National Open Access policies adopted	Yes, OA policies for research data [2013]; Yes, OA policies for scientific publications [2013]										
Priority 5 Composite	2016	63	2	54	41			<i>Not computed</i>			
Priority 6	Collab papers w/non-ERA per 1 000 researchers ^(c)	2014	44.7	2	-12	50.7	2005-2014	13.8%		9.7	4.1%
	Share of doctoral students from outside EU ^(c)	2012	20.3%	2	-20	25.5%	2005-2012	-0.1%		-3.6	3.5%
	Licence & patent rev. from abroad, share of GDP ^(c)	2013	1.29%	2	102	0.64%	2006-2013	5%		-4.3	9.6%
	Co-invention rate w/non-ERA partners ^(c)	2011-13 (R)	11.6%	2	18	9.8%	2007-2013 (R)	5.0%		2.7	2.3%
Priority 6 Composite	2016	67	2	22	55			<i>Not computed</i>			

COUNTRY NARRATIVE

Luxembourg is making progress towards its contribution to achieve the European Research Area (ERA). Overall, their performance falls above the average ERA and EU-28 levels, as evidenced by their Cluster 2 placement (relative to the ERA average) and 12 % lead over the EU-28 average on the headline composite indicator. Note that this composite score relies on the core high level indicators that were selected as being the most relevant in monitoring progress in achieving the ERA by the European Research Area and Innovation Committee (ERAC Secretariat, 2015). As such, it provides only a partial view of all the relevant and complementary dimensions captured by the indicators listed in the above table. The reader should be careful in extracting conclusions on overall performance, acknowledging the presence of variability across all the dimensions within and between priorities.

1. More effective national research systems

Luxembourg's performance in Priority 1 falls slightly above average overall, with most indicators placing in Cluster 2, while it records a 2 % gap relative to the EU-28 average on the priority composite.

Luxembourg's government budget appropriations or outlays for research and development (GBARD) as both a share of gross domestic product (GDP) and of government expenditures are slightly higher than EU-28 average, with leads of 7 % and 22 % in 2014, respectively. Over the 2008-2014 period, Luxembourg's GBARD as share of GDP underwent a steady trend of positive growth, increasing on average by 8.3 % per year. GBARD as a share of government expenditures saw an even greater increase of 12.5 % per year, on average.

The research sector in Luxembourg is small and relatively new, so most of the programmes tend to be thematic and receive funding through the Luxembourg National Research Fund's (FNR) CORE Programme. Due to slow budget increases, a merger of funding instruments was undertaken in order to maximise the potential of project calls for the period 2014-2017. However, most of the public funding for research and development (R&D) is allocated at an institutional level (70 %), with the rest being allocated on a project basis (Jonkers & Zacharewicz, 2016). Luxembourg's multi-annual funding plans have allowed the public research system to remain stable, despite flat government budgets (Alexander & Slavcheva, 2016). While there is no data available for the R&D tax incentives indicator in Luxembourg, it is hoped that as the research sector matures, private enterprises will invest more into R&D (Alexander & Slavcheva, 2016).

Luxembourg had 33 % more researchers per 1 000 active population than EU-28 average in 2014. However, the number of patent applications and publications per 1000 researchers fell below the EU-28 average by 23 % and 32 %, respectively. Considering that Luxembourg's research sector is relatively young, the country performs well in this priority and the trend is positive.

2. Optimal transnational co-operation and competition

Despite variable performance between sub-priorities 2a and 2b, Luxembourg's overall performance in Priority 2 is very strong, placing it in Cluster 1 relative to the ERA average and leading the EU-28 average by 32 % on the priority composite indicator.

a. Jointly addressing grand challenges

Luxembourg is a leader across most of the indicators in Sub-priority 2a, falling into Cluster 1 and posting performance scores far exceeding those of the EU-28. The exception is in GBARD allocated to transnational cooperation programmes, for which Luxembourg still performs above the EU-28 level but falls below the ERA average (i.e. into Cluster 3). Luxembourg has made notable and consistent progress in this regard in recent years, posting a mean annual growth rate of 35.2 % over 2010-2014, exceeding the EU-28's growth rate by 27.4 percentage points. This reflects the country's financial dedication to cross-border collaboration through funding, and is in line with evidence presented elsewhere regarding Luxembourg's relatively strong commitment to transnational cooperation despite its small size (Alexander & Slavcheva, 2016).

Luxembourg participates in seven ERA-NETs, as well as European Cooperation in Science and Technology (COST) programmes, ESF Networking Programmes, and a number of other

transnational programmes. This commitment to transnational cooperation is evident in the public-to-public partnerships (measured in EUR/researcher), where it has a lead of 454 % over the EU-28 average and thus falls into Cluster 1. Luxembourg also holds a leading position in its propensity to publish papers and patent inventions with collaborators within the ERA, falling into Cluster 1 on both indicators and leading the EU-28 average by 101 % and 324 %, respectively.

Funding is offered for bilateral and multilateral cooperation with ERA countries through the INTER programme, which promotes cross-border cooperation. In 2014, the INTER programme distributed EUR 6.14 million in project funding (Alexander & Slavcheva, 2016). In order to raise its international R&D profile, Luxembourg's lead funding agency has established agreements with the lead funding agencies in Germany and Switzerland, DFG and SNF respectively, so that it can define principles for future common projects in R&D.

b. Make optimal use of public investments in research infrastructures

Luxembourg's participation in early phase European Strategy Forum on Research Infrastructures (ESFRI) projects, as well as established landmark projects, is relatively low. Indeed, in 2016 Luxembourg participated in no early phase projects while participating in only 3.4 % of landmark projects. Despite these relatively low scores in overall ESFRI participation, Luxembourg participates in the pan-European DARIAH and SHARE infrastructures (Alexander & Slavcheva, 2016).

Luxembourg does not currently have a dedicated national research infrastructure roadmap in place but it will develop such a roadmap in its national ERA roadmap. However, even in the absence of a national roadmap, the country has been undertaking a large infrastructure project called The City of the Sciences (Alexander & Slavcheva, 2016). The project has funding close to EUR 1 billion, and its main objective is to provide world-class research facilities for Luxembourgish research performing organisations (RPOs) and the University of Luxembourg.

3. An open labour market for researchers

Luxembourg performs well in Priority 3, falling into Cluster 1 and exceeding the EU-28 average performance score by 25 % on the priority composite indicator.

Luxembourg surpasses the EU-28 average by 57 % on the headline indicator of EURAXESS job ads per 1 000 researchers in 2014, despite having experienced a steep annual decline averaging 26 % per annum in the 2012-2014 period. This trend went against that of the EU-28, which increased by an average of 7.8 % each year over the same period. Still, Luxembourg's system also led the EU-28 average (by 29 %) in open, transparent and merit-based hiring in 2012.

Luxembourg's lead funding agency provides funding to attract researchers from abroad, with 2015 data indicating that most researchers in Luxembourg are indeed foreign (Alexander & Slavcheva, 2016). The PEARL programme's objective is to bring top senior researchers to Luxembourg, in order to develop a project and oversee a team of their choosing; the programme has a budget of EUR 25 million for the period 2014-2017.

While there is no data available for the indicator of the share of PhD students from other ERA countries in Luxembourg, the EUR 10 million ATTRACT programme seeks to entice young researchers to Luxembourg's facilities (Alexander & Slavcheva, 2016).

4. Gender equality and gender mainstreaming in research

Priority 4 is an area in which Luxembourg has room for improvement, as indicated by its Cluster 4 placement and overall performance score on the priority composite indicator lagging behind the EU-28 average by 35 %.

Relative to its ERA country counterparts, Luxembourg falls into the lowest performance cluster for the share of women among heads of higher education institutions and among researchers; it also falls into Cluster 4 in its degree of specialisation in the inclusion of a gender dimension in research content. While falling into a higher cluster than the preceding indicators, Luxembourg also falls behind both the ERA and EU-28 averages in the share of women among Grade A positions in the higher education sector.

On a positive note, however, Luxembourg has been making strides towards closing these performance gaps in recent years, having exhibited annual growth rates equal to or exceeding the EU-28 level. This was particularly notable for the share of women in Grade A positions, which rose by an average of 8.6 % over the 2007-2014 period. If this upward trend continues, Luxembourg will be able to continue making progress towards improving gender equality and gender mainstreaming in research.

5. Optimal circulation, access to and transfer of scientific knowledge including via digital ERA

Despite a wide degree of variability across individual indicators, Luxembourg's overall performance in the areas of knowledge transfer and open access is quite good as evidenced by a Cluster 2 ranking and 62 % lead over the EU-28 average on the priority composite indicator.

a. Knowledge transfer

Luxembourg's performance in Sub-priority 5a is mixed, although it generally falls below average ERA and EU-28 levels and in some cases had declined in recent years. In terms of collaborating with the private sector, research institutes in Luxembourg fare better than higher education institutions, with the former having exceeded the EU-28 average by 6 % in 2012 while the latter trailed behind by 41 %. Both indicators lost ground to the EU-28 average over the 2008-2012 period, however, trailing the annual growth by more than 10 % in both cases. Public R&D funded by the private sector also fell behind 2013 EU-28 levels (by 72 %), although the mean annual increase of 8.9 % between 2009 and 2013 suggests that Luxembourg is making strides towards closing this performance gap.

In contrast to the lower performance scores observed in other Sub-priority 5a indicators, papers published in collaboration between the public and the private sectors exceeded the EU-28 average by 18 % in 2014.

Despite this variable performance, Luxembourg's general R&I strategy is strongly oriented towards public-private partnerships (Alexander & Slavcheva, 2016). In an effort to maximise the potential of knowledge transfer (KT), as well as commercialisation, proposals submitted to the CORE programme are evaluated by LuxInnovation (Luxembourg's national agency for innovation and research) for their commercialisation potential (Alexander & Slavcheva, 2016). The Knowledge and Innovation Transfer Support (KITS) programme, launched in 2015, is aimed at integrating professionals in the area of knowledge transfer between universities and the private sector. Similarly, the Proof of Concept programme provides funding to RPOs to help make their ideas more attractive to potential investors. Several business incubators as well as start-up incubators exist in Luxembourg, primarily in the newly-built City of Sciences complex.

b. Open access

Luxembourg is a leader in the area of open access, falling into Cluster 1 for both the total share of papers in open access as well as the share of papers in green open access, with performance scores in 2014 leading the EU-28 average by 17 % and 28 %, respectively. The share of papers published in gold open access, however, trailed the EU-29 average by a marginal 2 % gap and led to a Cluster 3 placement for this indicator.

In an effort to further increase researchers' access to publications and data, the Luxembourg University Library will be transformed into a National Open Access Office for Luxembourg (Alexander & Slavcheva, 2016). Furthermore, the country has policies in place relating to the open access of both data and publications.

6. International cooperation

Luxembourg performs well in Priority 6 overall, posting a lead of 22 % over the EU-28 average and falling into Cluster 2 on the priority composite indicator.

Luxembourg has co-funding agreements with several third-party countries, including the United States' National Science Foundation and National Aeronautics and Space Administration (NASA) Ames Research Centre, as well as the Institute for Physical and Chemical Research (RIKEN) in Japan (Alexander & Slavcheva, 2016). While Luxembourg's share of papers published in

collaboration with partners outside of the EU trailed 12 % behind the EU-28 average in 2014, the country's continuous positive growth trend between 2005 and 2015 (averaging 13.8 % per year) suggests that they are catching up. Luxembourg's share of doctoral students from outside of the EU also fell behind the EU-28 average, although it was above-average in this regard relative to the wider ERA average (as evidenced by its Cluster 2 placement).

Luxembourg's strongest performance in this priority is in licence and patent revenue from abroad as a share of GDP in 2013, which at 1.29 % exceeded the EU-28 average by 102 %. The country also holds an 18 % lead relative to the EU-28 average in regard to the co-invention rate with partners outside of the ERA.

Summary

Taking into account the small size of the country and its relatively young research sector, Luxembourg is performing well towards the achievement of the ERA. However, certain areas require catching up to the performance of its European counterparts (at both ERA and EU-28 levels). While Luxembourg has a very high rate of collaboration with its ERA partners through co-patenting and co-authoring papers, it lacks a national roadmap for research infrastructures and participates in very few ESFRI-related initiatives. Nevertheless, Luxembourg's weakest performance is in Priority 4, where it falls into the lowest performance cluster and lags behind the EU-28 average by 35 % on the priority composite indicator. Indeed, women in Luxembourg are underrepresented across all indicators except among PhD graduates, and the country also underperforms in the inclusion of a gender dimension in research content.

Luxembourg's strengths lie primarily in Priorities 2a, 3 and 5. The country also excels at bringing in revenues from licences and patents from abroad (Priority 6). The success of this indicator could be at least partially related to the national funding agency's requirement that proposals submitted through the CORE programme must be evaluated for their commercialisation potential. Overall, Luxembourg is well on its way to achieving the ERA.

Luxembourg published a summary of its 2016 National Action Plan (also called an ERA national roadmap), while drafting the full document. This summary includes the main objectives for all priorities. For instance, in regard to Sub-priority 2a (in which Luxembourg has room for improvement for transnational cooperation), objectives outlined are as follows: (a) 'Increase national participation in the third pillar ("Societal Challenges") of Horizon2020', and (b) 'Increase the number of bi-lateral partnerships with EU Member States' while in regard to Priority 4 (in which Luxembourg has more room for improvement), objectives outlined are as follows: (a) 'Increase the percentage of the underrepresented sex in leadership and decision-making positions', and (b) 'Apply gender mainstreaming in public research programmes States' (Ministère de l'enseignement supérieur et de la Recherche, 2016).

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ANNEX: METHODOLOGICAL NOTES

	Indicator	Data availability	Flag								
			Exception to ref. year	Exception to ref. period	Break in time series	Definition differs	Estimated	Provisional	Potential outlier	Revised	Eurostat estimate
Priority 1	Adjusted Research Excellence	Available									
	GBARD as share of GDP	Available									
	European Innovation Scoreboard	Available									
	<i>GBARD as share of government expenditures</i>	Available									
	<i>R&D tax incentives as share of GBARD</i>	Unavailable									
	<i>Share of GBARD allocated on project basis</i>	Available									
	<i>Patent applications per 1 000 researchers</i>	Available					2007				
	Researchers per 1 000 active population	Available			2007, 2009		2007, 2014	2014			
Publications per 1 000 researchers	Available					2007, 2014	2014				
Priority 2	A - GBARD to transnatl coop (EUR/researcher)	Available					2007, 2014	2014			
	A - Collab papers w/ERA per 1 000 researchers	Available					2007, 2014	2014			
	A - Public-to-public partnerships (EUR/researcher)	Available					2014	2014			
	A - Co-invention rate w/ERA partners	Available									
	B - Roadmap for ESFRI projects	Available									
	B - Participation in developing ESFRI projects	Available									
B - Participation in operational ESFRI landmarks	Available										
Priority 3	EURAXESS job ads per 1 000 researchers	Available					2014	2014			
	Open, transparent, merit-based hiring process	Available									
	Share of doctoral students from EU countries	Unavailable									
Priority 4	Share of women among Grade A HES	Available	2013	2006-2013							
	Gender dimension in research content	Available									
	Share of women among PhD graduates	Available		No Cagr							
	Share of women among heads of HEI	Available	2010								
	Share of women researchers	Available					2007				
Priority 5	A - Research institute-private collaboration	Available				2012					2012
	A - Higher education-private collaboration	Available									
	A - Share of public R&D funded privately	Available			2010-2013						
	A - Public-private collab papers per capita	Available			2010-2013						
	B - Share of papers in Open Access (Total)	Available									
	B - Share of papers in Open Access (Green)	Available									
	B - Share of papers in Open Access (Gold)	Available									
B - National Open Access policies adopted	Available										
Priority 6	Collab papers w/non-ERA per 1 000 researchers	Available					2007, 2014	2014			
	Share of doctoral students from outside EU	Available									
	Licence & patent rev. from abroad, share of GDP	Available							2013		
	Co-invention rate w/non-ERA partners	Available									

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The European Research Area (ERA) Progress Report 2016 shows the state of play in ERA. A lot has happened in the European research landscape since the last edition in 2014. The ERA Roadmap at EU level was endorsed by the Council in early 2015. This called for top action priorities that will have the biggest impact on Europe's science and innovation systems. Member States were invited to draw up national action plans based on this approach. Last year almost all Member States and a number of Associated Countries have published their National Action Plans on ERA showing clear political ownership of ERA.

This analysis carried out in 2016 shows strong progress in all ERA priorities across the EU. This was possible because of a true partnership among the Member States and Associated Countries, the Commission and research stakeholder organisations. But we cannot be complacent. European strength in the field of Research and Innovation is needed more than ever to reinforce competitiveness but is also increasingly challenged to deliver on impacts. The Commission's policy agenda on Open Science, Open Innovation and Open to the World will open up ERA to future challenges, like digitalisation and global networks. There are new barriers to break down to create more wealth and security for our citizens.

Studies and reports

