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Abstract
The 2015 series of RIO Country Reports analyse and assess the policy and the national research and innovation system developments in relation to national policy priorities and the EU policy agenda with special focus on ERA and Innovation Union. The executive summaries of these reports put forward the main challenges of the research and innovation systems.

Table of Contents

Foreword

The report offers an analysis of the R&I system in Poland for 2015, including relevant policies and funding, with particular focus on topics critical for EU policies. The report identifies the main challenges of the Polish research and innovation system and assesses the policy response. It was prepared according to a set of guidelines for collecting and analysing a range of materials, including policy documents, statistics, evaluation reports, websites etc. The quantitative data is, whenever possible, comparable across all EU Member State reports. Unless specifically referenced all data used in this report are based on Eurostat statistics available in February 2016. The report contents are partly based on the RIO country report, 2014 (Klincewicz, 2015a).

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Executive summary

Context

The Polish economy has weathered the recent global financial crisis particularly well. Nevertheless, the economy still relies on labour cost competitiveness model. Poland made relatively little progress towards increasing the importance of medium and high-technology products and services. As pointed by many reports, further efforts should be made to avoid the middle income-trap (Bogumił, Wielądek, 2014; McKinsey, 2015).

Poland was subject to the Excessive Deficit Procedure since July 2009 (till June 2016), when the Council issued a recommendation calling for its deficit to be corrected by 2012. The R&D budget appropriations (GBAORD) increased even in the years of the crisis and were not subject to consolidation within the excessive deficit procedure. Yet, part of the increase was gained through using the EU Structural Funds and their role increases year by year, which in the longer term (after 2020) may pose a problem with sustaining the levels of public spending on R&D.

The Polish research and innovation (R&I) system has been significantly restructured since its 2010-2011 reform, but those changes have not yet triggered significant changes to output indicators. Poland once again scored poorly in the EU's 2015 Innovation Union Scoreboard ranking as moderate innovator and lags in the Research Excellence indicator.

GERD as percentage of GDP in 2014 was 0.94%, which remained well below the target of 1.70%, set for 2020, but it is steadily increasing every year. The R&D funded by the business sector amounted in 2014 to 0.44% of GDP (EU-28: 1.3% in 2014) and the business expenditures on R&D have gradually increased in recent years (2010-2014). Public expenditures on R&D remain the main source of funding (47.4% of GERD in 2014). The European Structural Funds are an important source of funding for R&D as well as Innovation activities, altogether the R&D funding from abroad accounted for 13.4% of GERD in 2014 (GUS, 2015b). GERD and BERD show a steady increase, and meeting the long-term targets is likely, especially with the substantial R&I allocations based on the 2014-2020 EU Structural Funds (13.2% of the total amount, i.e. €10.14b over seven years).Share of public R&D funding distributed as grants (project funding) was 65.14% in 2014.

Key developments in the R&I system in 2015 included:

- adoption of the Operational Programme Smart Growth (POIR) and 16 regional operational programmes, which will offer substantial financing for R&I initiatives, based on the EU Structural Funds in the 2014-2020 perspective;
- adoption of National Smart Specialisations (KIS) and regional smart specialisations, listing strategic areas for R&I support;
- launch of a new portfolio of support measures, based on POIR and offered by multiple government agencies – the redesigned R&I support system includes instruments covering the entire innovation cycle, and encompasses both grants and financial instruments, with the involvement of experienced investment funds and public-private partnerships;
- amendments of the Act on Principles of Financing Science to facilitate large investments in research infrastructures in line with the national roadmap; adoption of the Act on Amendments of Some Acts with respect to the Support for Innovativeness, adjusting tax accounting regulations for R&D, and including changes to various other legislations, intended to streamline Poland's innovation system and eliminate the identified bottlenecks.

Poland is aligned with many ERA policies, but the R&I system suffers from insufficient internationalisation. There are restrictions on access to and portability of grants and international scientific co-operation is limited compared to other EU member states.

Despite only limited incentives to publish in open access, the statistics show relative popularity of this mode of publishing in Poland.

The Polish R&I policies show in the current years a strong focus on the promotion of knowledge transfer and science-based entrepreneurship, with additional measures taken to promote the development of the venture capital market, but tangible results of these efforts are still to be seen.

The identified challenges for Poland's R&I system are:

(1) Increase intensity of private R&I –unsatisfactory R&D investments of business enterprises are coupled with low reliability of BERD data;

(2) Strengthen cooperation between science and industry – collaboration remains limited and therefore restricting the innovative potential of the economy;

(3) Increase quality of the public science base – in response to the present, excessive focus on quantity of output rather than quality and relatively low research productivity;

(4) Attract R&D-focused FDIs and create knowledge spill-overs from FDIs –many foreign investors are still attracted by the low labour costs and favour low-to-medium-tech manufacturing investments, with the government policies starting to target knowledge-driven ventures;

(5) Set priorities in the R&I governance system – the concentration of financial resources on key strategic areas and R&I priorities is expected to increase the effectiveness of investments in line with the national and regional smart specializations.

R&I Challenges

Challenge 1: Increase intensity of private R&I

Description

Poland has been gradually increasing the business expenditures on R&D as a result of the catching-up process with its Western European counterparts (0.18% of GDP in 2010 to 0.44% in 2014, more than double in nominal terms). Yet, it continues lagging behind most EU countries, also when compared with its neighbours (1.12% of GDP in CZ and 0.98% in HU in 2014). Even though the actual business R&D expenditure might be underestimated due to the lack of appropriate incentives for businesses to report them and/or qualify them as R&D costs (Kapil et al., 2012; EC, 2015: 23), the innovation output indicators show little progress towards a more innovation-driven economy. Poland scores particularly low on the criteria related to SMEs innovating in-house and SMEs introducing innovations (last or second to last among 34 countries included in the ranking), with a declining trend in 2007-2012 for product or process innovation

The European Council reiterated in its country-specific recommendations in 2014 (CEU, 2014) the importance of introducing new tax incentives for R&D as a way to leverage R&I spending by the business sector. The existing tax incentives are either used by a limited number of large companies that either register a R&D centre (42 companies in 2015) or acquire technology (80 beneficiaries in 2014). Even the official government documents confirm that "the existing system, intended to support innovativeness of enterprises, favours the purchases of ready-to-use solutions, thus supporting transfers of foreign solutions", as spelled out in the background document, prepared in 2012 by the Ministry of Economy for the "Strategy for the Innovation and Efficiency of the Economy for the years 2012-2020" (MG, 2012).

Policy response

The Enterprise Development Programme for the years 2014-2020, adopted in 2014 and implementing the high-level Strategy 'Dynamic Poland' contains a comprehensive list of planned measures to support the development of innovation and entrepreneurship including tax incentives for R&D. The national smart specialisation strategy is an integral part of the document.

The science and higher education reforms from 2010-2011 established the operations of two executive funding agencies for basic research and applied research. The National Centre for Research and Development leverages business R&D spending by introducing multiple grant programmes as public-private partnerships (e.g. BRIdge, CuBR). The principle is also used for sectoral programmes financed from the Structural Funds 2014-2020 (e.g. INNOMED or INNOLOT). In 2014, the average private co-funding from business enterprises in all programmes funded by NCBiR amounted to 23%[1]. The NCBiR requests its beneficiaries to adequately report their own financial contributions in order to better account for the BERD.

The Polish Agency for Enterprise Development offers innovation vouchers stimulating collaboration between SMEs and research institutions (in 2002-2012, a total of 30.6m PLN/ €7.3m was distributed among 2,053 entities). The allocations per voucher were subsequently enlarged and are offered also in the current programming period. In parallel, similar instruments are also offered by some of the regions. Overall, the programming of the EU Structural Funds for 2014-2020 in Poland was guided by an explicitly stated shift in focus from financing technology absorption to technology development with several measures focused on launching new services and products (e.g. PARP-managed Research for the market and NCBIR-managed DEMONSTRATOR+ or Applied projects).

[1] NCBiR Annual Report 2014.

The Act on Amendments of Some Acts with respect to the Support for Innovativeness adopted in September 2015 introduces the definition of R&D efforts to the Polish tax accounting system and allows companies to classify parts of the R&D expenditures as tax deductible costs as from 2016 which is aimed at increasing R&D business expenditures. The initial version of the Act included substantial tax exemptions for R&D performers, but they were removed in the subsequent parliamentary work.

Assessment

The effects of the science and higher education reforms from 2010-2011, increasing focus on leveraging business R&D in the current programming period (in line with the national smart specialisation strategy) and recent changes in the tax accounting system are likely to generate further increases of BERD in the coming years. Increasing shares of researchers employed by business enterprises (from 16% in 2010 to 29% in 2013) are signs of growing research capacity of business. The implementation of R&D tax breaks foreseen in the Enterprise Development Program has the potential to further increase R&D expenditures, but the implementation was put aside in 2015.

Challenge 2: Strengthen cooperation between science and industry

Description

The weak linkages between business sector and academia continue to be a challenge for the young Polish R&I system and were subject of Country Specific Recommendations in 2011 and 2013. The bulk of business expenditures in the last years was on technology absorption (that was supported both by the system of tax incentives, which included the tax relief for technology acquisition, and by the EU Structural Funds in 2007-2013). On the supply side, the academia still lacks sufficient skills in R&D commercialisation and until recently was not incentivised to look for new sources of financing, since the share of institutional funding was very high and commercialization of R&D results is still not part of the formal career evaluation of individual researchers.

The knowledge transfer outcomes remain unsatisfactory. The number of research projects carried out by PHEIs and PROs that were contracted by the industry remains persistently low (with business funding of research performed by academia amounting to 0.02% of the GDP, one of the lowest in the EU-28). Only 10.5% of innovative companies cooperate with universities and higher education institutions compared to almost 15% in CZ and 18% in HU (CIS, 2012). Counts of joint patent applications are insignificant and in 2013, Poland had only 9.8 public-private co-publications per million of population compared to 29 for the EU-28 (and 17.5 for CZ, 12.8 for HU)[2].

Policy response

The Enterprise Development Programme for the years 2014-2020 foresees the simplification of IP rules for public research institutes, strengthening science-business links through regional instrument financing private sector secondments of academics.

The science and higher education reform from 2010-2011 was intended to induce synergies between the science and industry sectors in order to stimulate the overall innovativeness of the economy. The amendments of the Act on Higher Education from 2011 introduced rules on special purpose vehicles to enable commercialisation of research at universities and reconfirmed the important role of academic incubators and Technology Transfer Offices (TTOs). The Act on Research Institutes (2010) laid out rules for pursuing research collaboration with the industry.

[2] RIO elaboration based on Scopus data.

The amendments to the Higher Education Act from 2014 foresee new rules for commercialisation of research in universities with a mix of university ownership and the inventor ownership model [3].

Still, the R&I support measures in 2007-2013 focused on 'brick and mortars' solutions (TTOs, incubators) rather than on fostering links between the actors (Klincewicz, 2015a).

One of the main objectives of the National Centre for Research and Development, as laid out in its foundation act from 2010, is the support for commercialization and other forms of transfer of scientific research results. The agency launched multiple knowledge transfer measures and introduces additional instruments for the 2014-2020 perspective, including "*BRIdge Alfa*" (seed capital for academic start-ups) and "*BRIdge VC*" (VC-type of funding for innovative, research-intensive companies), combining the EU funding with the capital provided by private investment funds. Other organisations in charge of this policy domain are: the Polish Agency for Enterprise Development (PARP), distributing innovation vouchers and funding for innovations not related to R&D and the Ministry of Science and Higher Education, running the *TOP 500 Innovators* programme supporting the development of human resources as well as the *Innovation Brokers* programme. The Industrial Development Agency established an IP trading platform to facilitate the match-making activities in the field of knowledge transfer. Additionally, the fundamental science funding agency (NCN) and the National Centre for Research and Development run jointly the programme *TANGO*, which is similar to the *ERC Proof of Concept* grants. The Foundation for Polish Science funds internships for Polish scientists in Polish and foreign companies through the SKILLS programme.

The Act on Amendments of Some Acts with respect to the Support for Innovativeness facilitates the transfer of intangible assets to newly created companies and lifts related taxes in 2016-2017.

Assessment

The strength of Poland lies in a well-aligned KT policy underpinned by long-term strategies and clear goals for the next seven years. Still, the output indicators (especially those with a long time lag as co-patenting or co-publications) are not satisfactory. The major weakness of the KT system is the demand side of the KT value chain linked to the low innovativeness of the Polish business sector and especially the SMEs (see challenge 1) The intersectoral mobility of highly skilled employees in science and technology is an important mechanism to foster knowledge circulation and transfer and those measures, announced in the Enterprise Development Program and implemented in the Operational Programme Smart Growth, 2014-2020, started only in 2015. Recent changes to the rules of IPR management concerning academic inventions were intended to stimulate the growth of knowledge markets by empowering the scientists to assume the ownership of their inventions, but PHEIs and PROs tend to exercise their rights to exploit the IPRs by themselves, so the impact of the new regulations on the science-industry collaborations remains ambiguous.

Challenge 3: Increase quality of the public research base

Description

Poland ranks low among research performers in the European Union, as evidenced by the score in the Research Excellence Output Indicator of the EU Innovation Union Scoreboard.

[3] For each academic invention, the university has three months to decide if it wants to commercialise the results (the researchers-inventors receive in such cases at least 50% of revenues minus 25% of commercialisation costs). If the decision is negative, the researcher can obtain the full rights to the related IP against a small fee and can freely decide on partners and ways of commercialization.

The share of the top 10% highly cited publications as full counting for the period of 2000-2013 was 5.39% (compared to 7.34% for the Czech Republic, 17.01% for the top-performing Denmark and 11.29% for EU-28). The Polish research output is also less internationally oriented with about one third of publications co-published internationally (the lowest value among all EU-28 Member States) (Scopus data 2013, RIO own calculations), as the evaluation system with its parametric system incentivises quantity rather than quality.

Another indicator of low performance of Poland is the fact that it benefited in total from only 1.1% of all FP7 funding allocated to beneficiaries from EU-28 and has even lower results in the first calls of Horizon 2020 – 0,1% (based on eCorda database).

However, the wide availability of alternative sources of funding for R&D, including state-funded programmes and the EU Structural Funds in the 2007 - 2013 period, was an important inhibitor for participation in more competitive European research programmes.

Policy response

Poland introduced performance-based funding models in 2008. Public research organisations and universities are encouraged to compete for the status of the leading national research centre (KNOW), which gives access to additional funding. In 2013, after the first national assessment based on new rules promoting the research effectiveness, the evaluation criteria were substantially modified to further promote organizations conducting world-class research, and the evaluation process is supported by a central IT system POL-on[4]. The assessment in 2017 will be carried out according to an updated methodology prepared after consultations with stakeholders. More points will be granted for the participation in international research projects with a special emphasis on Horizon 2020, or for receiving the HR Excellence in Research logos.

Dedicated funding instruments support also the internationalization of the Polish R&I system, including grants targeting international co-operation and for years 2014-2020, the support is being strengthened thanks to new, dedicated measures. The EU Structural Funds are used to support the launch and delivery of innovative doctoral studies, with preference for interdisciplinary programmes, involving international researchers and science-industry collaboration. MNiSW signed a voluntary agreement of with interested PHEIs and PROs ("Pact for Horizon 2020"), ensuring additional support for research teams that apply for funding and implement Horizon 2020 projects. The Ministry launched also the Information System on Science (POL-on) –aggregating data about researchers, research infrastructures, publications and R&D projects of PHEIs and PROs in order to better monitor the performance of the system. A good example of support for research excellence are the highly-selective R&D funding programs offered by the Foundation for Polish Science (FNP), oriented towards internationally competitive projects.

The Ministry recently prepared the Programme for Internationalisation of Polish Higher Education. The document presented in June 2015 does not introduce any new financial commitments, nor does it include an Action Plan to implement it, but only aggregates the existing support measures.

Assessment

Recent efforts to increase the funding for international co-operation and raise the Horizon 2020 success rates as well as the increase in the share of the public funding for best performers should be closely monitored. Given the low share of international tertiary students and researchers, more efforts are needed to attract excellent researchers from abroad to further open and internationalise the Polish research system.

[4] http://polon.nauka.gov.pl/ankieta-jednostki

Challenge 4: Attracting R&D focused FDI and creating knowledge spill-overs from FDIs

Description

The FDI policies of the Central and Eastern European countries were focused on FDI inflows with the main aim of generating employment in less economically developed regions. Yet, this focus on cost competitiveness attracted mostly low to mid-low technology and required a relatively low-skilled labour force (Radosevic, Stancova, 2015). As a result, even though Poland experiences a constant influx of foreign direct investments, being one of the most attractive FDI locations in the EU, its main strength still lays in relatively cheap labour. Yet, the character of the largest FDIs in Poland gradually evolves towards knowledge-based activities (the amount of R&D expenditures by FDIs more than doubled from 2009 to 2013, growing from €300.79m to €694.17m according to the national statistical office).

Policy response

In 2014, the government amended the rules for the "Programme for the support of investments of considerable importance for Polish economy for years 2011-2020", which supports FDIs and will be oriented towards R&D-type investments, with specific funding allocated by the Ministry of Economy. The amendments include incentives for R&D investments, and investors from priority sectors (automotive, electronics, aviation, biotechnology, business services sector). The government agency dealing with foreign investments, PAIZ, treats R&D investments as a priority, with focused efforts of PAIZ specialists interacting with potential investors. The National Centre for Research and Development cooperates with foreign VCs, co-funding the establishment of a dedicated fund to support the commercialization of R&D-based companies.

Assessment

This change in policy focus is already visible in the registered increase in R&D funding by foreign investors in 2012 and 2013. The introduction of R&D tax credits similar to neighbouring countries (e.g. CZ) would probably offer additional incentives for R&D-intensive FDIs. So far little attention was paid to the creation of linkages between the foreign enterprises, local companies and/or scientific organisations.

Challenge 5: Priority setting in the R&I governance system

Description

In the past, both investors and R&D performers were facing problems in identifying clear priorities in the government's R&I support policies. The European Commission in its 2012 Country Specific Recommendations pointed out to the need for higher concentration of investments in priority areas. The government defined a list of 20 National Smart Specialisations based on foresight exercises and in a similar manner, each of 16 Polish regions established RIS3, defining eligibility of funding for R&I and research infrastructures from the Operational Programmes. The EC has already pointed out to limited synergies between the national and regional levels, which become important as more of the EU Structural Funds will be directly distributed on the regional level in 2014-2020.

Policy response

The Strategy for Innovation and Efficiency of the Economy – Dynamic Poland 2020 (2013-20) and the Entrepreneurship Development Programme including National Smart Specialisations set the strategic directions for R&I policy and implementation.

In the current programming period, the national R&D-related measures managed previously by many governmental agencies are mainly co-ordinated by the National Centre for Research and Development to avoid competence overlaps among government agencies, and the agency signed agreements with several regional governments to support the management of the regional R&D programmes.

The entrepreneurial discovery process is supported by the World Bank in order to improve the engagement of stakeholders such as business enterprises in the formulation of innovation policies and the identification of emerging specialisations (OECD, 2014).

Assessment

Top-level policy documents define targets and implementation plans in R&I area. With the increasing importance of the regions in channelling R&I funds, the voluntary agreements of regional governments and NCBiR are an important sign of good coordination between governance levels. Yet, the European Commission calls for more evidence that the newly proposed RIS3 framework goes beyond the "business as usual" from the previous EU financial perspective (2007-2013), which was focused on technology absorption and a generic distribution of funds rather than innovation of domestic companies and technology transfer in selected areas, identified as smart specialisations. 'Gold plating' especially at the regional level should also be closely monitored, as in previous programming period the regional distribution of funding was seen as problematic by beneficiaries[5] (Klincewicz, 2015a).

[5] It refers to obligations that go beyond the standard EU requirements: an excess of norms, guidelines and procedures accumulated at national and regional levels, interfering with the expected policy goals.

1. Overview of the R&I system

1.1 Introduction

Poland had 38.49m inhabitants in 2014 (7.58% of the EU population) and was the EU's 7th largest economy. The country had experienced constant GDP increases in recent years, despite the economic crisis, which affected other EU member states. The GDP growth rate was 1.8% in 2012, 1.7% in 2013 and 3.4% in 2014, compared with the EU average of 1.3% (2014), and Poland belonged to the fastest growing economies in the EU (Eurostat, 2015). GDP per capita was €10,000 in 2012, €10,300 in 2013 and €10,700 in 2014, remaining far below the EU average of €27,300 (2014) (Eurostat, 2015). Poland's budget deficit was reduced in recent years, reaching -3.2% in 2014, i.e. similar to the EU average of -2.9% (2014) (Eurostat, 2015), and in 2015, Poland was released from the excessive deficit procedure of the EU. Government debt of 50.1% of GDP was in 2014 lower than the average EU figure of 86.8%, and the debt ratio had declined compared with the preceding years (Eurostat, 2015). Unemployment rate of 9.0% in 2014 had also declined compared with 2012 (10.1%) and 2013 (10.3%), remaining lower than the EU-wide rate of 10.2% (2014) (Eurostat, 2015).

Polish economy is dominated by manufacturing and agriculture sectors, but the role of the service sector is increasing. Polish manufacturing relies mostly upon low-tech and low-to-medium-tech operations, and the value added by the high-tech manufacturing in 2012 only amounted to 1.3% of the total value added in the national economy, nearly half the EU average of 2.5% (Eurostat, 2015). Polish GERD converted to Euro (€)[6] was €3,864.016m in 2014, with GERD per capita growing from €39.6 in 2006 and €74.5 in 2011 to the levels of €90.1 in 2012, €90.3 in 2013 and €101.6 in 2014 (Eurostat, 2015). The increases of GERD per capita were substantial: 240.94% for 2004-2014, and 119.44% for 2007-2014, far exceeding the parallel increases in the GDP per capita (98.15% for 2004-2014 and 30.49% for 2007-2014) (Eurostat, 2015). Nevertheless, the GERD to GDP ratio is still low in relation to expenditures incurred by many other EU member states: 0.89% in 2012, 0.87% in 2013 and 0.94% in 2014, compared with the EU average of 2.03% (2014) (Eurostat, 2015). Turnover from innovations was 6.3% of the total turnover in 2012, nearly half of the EU average of 11.9% for the same year (Eurostat, 2015).

Polish R&D investment target set for 2020 is 1.7% GERD to GDP ratio, with business enterprises accounting for half of the GERD (BERD as 0.85% of GDP). Meeting the target is probable thanks to the wide availability of R&D co-funding from the EU structural funds, support measures intended to stimulate private expenditures on R&D, campaigns raising awareness of the importance of R&I investments by business enterprises, and constant increases in the share of government budget allocated for science. Poland did not experience the economic crisis in 2008, but merely a slow-down in the still positive GDP growth, and even at times when some government budget allocations had to be reduced due to adverse economic conditions, the public spending on R&I remained intact. The science budget for 2015 was the highest in Poland's history (€1,747m according to budgetary plans) and the budget, adopted by the government in September 2015 and amended in December 2015, foresees a further increase in the year of 2016. In addition, Poland allocates a substantial share of the GDP as defence expenditures, and many large-scale projects planned for 2016 and 2017 involve R&D performed by business enterprises.

[6] Monetary data presented in the report were converted from PLN to Euro using the average annual exchange rates, published by NBP: 1€ = 4.1082 PLN (2009), 1€ = 3.9946 PLN (2010), 1€ = 4.1198 PLN (2011), 1€ = 4.1850 PLN (2012), 1€ = 4.1472 PLN (2013), 1€ = 4.1852 PLN (2014).

In 2014, Poland was the 5th most popular EU destination for foreign direct investments according to a report by Financial Times (fDi Intelligence, 2015: 8), improving its ranking position from the 9th place in the EU in 2014 (fDI Intelligence, 2014: 6). The Polish economy was also relatively highly positioned in the World Bank's ranking "Doing Business 2015", where Poland was ranked 32nd, with only 13 EU member states ranked higher (World Bank, 2014). In early 2015, Poland concluded the negotiations of the Operational Programme Smart Growth (POIR), based on the EU Structural Funds and intended to support R&I, and first calls were launched already in April 2015, thus demonstrating the efficiency of government agencies.

The parliamentary elections in October 2015 were lost by the centre-right party Civic Platform (PO) and its coalition partner, the agrarian Polish People's Party (PSL), who have stayed in power for the past 8 years. The new ruling party is the right-wing Right and Justice (PiS). The change in government might introduce major discontinuities in R&I policies and programs, especially as PiS used to criticize the PO's approach to innovations and science in recent years. The science budget was not reduced by the new government. The main change to R&I policies in 2015 was the integration of two ministries to create a large institution overseeing economic, innovation, infrastructure and regional development policies (the Ministry of Economic Development)[7].

[7] More changes were announced in 2016 and will be subject of analysis in 2016 edition of the RIO Country Report.

Table 1. Main R&I indicators, 2012-2014

Indicator	**2012**	**2013**	**2014**	**EU average (2014)**
GDP per capita	10,000	10,300	10,700	27,300
GDP growth rate	1.8%	1.7%	3.4%	1.3%
Budget deficit as % of GDP	-3.7%	-4.0%	-3.2%	-2.9%
Government debt as % of GDP	54.4%	55.7%	50.1%	86.8%
Unemployment rate as percentage of the labour force	10.1%	10.3%	9.0%	10.2%
GERD in €m	3,429.852m	3,436.284m	3,864.016m	283,009.388m (total for EU-28)
GERD as % of the GDP	0.89%	0.87%	0.94%	2.03%
GERD (EUR per capita)	90.1	90.3	101.6	558.4
Employment in high- and medium-high-technology manufacturing sectors as share of total employment	4.9%	5.0%	NA	5.6% (2013)
Employment in knowledge-intensive service sectors as share of total employment	30.6%	31.2%	NA	39.2% (2013)
Turnover from innovation as % of total turnover	6.3%	NA	NA	11.9% (2012)
Value added of manufacturing as share of total value added	30.5%	NA	NA	26.2% (2012)
Value added of high tech manufacturing as share of total value added	1.3%	NA	NA	2.5% (2012)

Source: Eurostat, 2015.

1.2 Structure of the national research and innovation system and its governance

1.2.1 Main features of the R&I system

The R&I system is dominated by public funding, but the role of private capital increased in recent years, with business enterprises accounting for a growing share of GERD (46.58% in 2014). Among private sector entities, the majority of R&D efforts are carried out by large companies, and companies controlled by foreign capital (including multinationals). National statistics report 2,467 business enterprises performing R&D in 2013, with majority of private sector R&D expenditures in industrial and ICT sectors (GUS, 2015a). 45,8% of private sector R&D expenditures were in 2013 incurred by enterprises controlled by foreign capital, and 63,4% - by large enterprises, with 250 or more employees (GUS, 2015a). Innovative activities of small and micro-enterprises are rarely included in official R&D statistics, but a thriving community of high-tech start-ups exists in Poland, benefiting from infrastructures and environments such as incubators, accelerators and from the public co-funding (as young technology-based companies are eligible for most R&I support measures targeting business enterprises). Universities and Public Research Organisations (PROs) engage both in research and technology transfers, with PROs more oriented towards applied R&D, but universities generate altogether more scientific publications and patent applications than PROs.

Poland is divided into 16 voivodeships (regions), and the regional diversity is mirrored by the differences in intramural expenditures on R&D, with the highest GERD per capita in Masovia (with the capital, Warsaw), Lesser Poland and Pomerania. In the 2014-2020 financial perspective of the EU Structural Funds, regions play important roles in distributing the R&I funding in addition to the centrally distributed funds. They've defined regional smart specialisation strategies, and will offer direct support for R&D, research infrastructures, knowledge transfer and other innovative activities, based on Regional Operational Programmes (RPOs). The growing importance of regions is an important change to the R&I system, but has not yet been visible in 2015 when regional support measures were still under preparation. Centrally distributed R&I funding will still dominate in the R&I system, but the new regulations are likely to promote the developments of diversified regional innovation systems.

1.2.2 Governance

R&I governance relies upon a relatively stable, central government bodies, with predictable, multi-annual policy planning and budgetary framework. The responsibilities for R&I policy are formalised and divided among selected institutions, with the planning horizon extending up to the year of 2023, represented in government strategies and programmes. The policies were elaborated in close co-operation with multiple groups of stakeholders, including representations of business enterprises, universities, public research organisations and regional authorities. In 2015, a stakeholder network was formed called the "Coalition for Polish Innovations" (pl. *Koalicja na rzecz Polskich Innowacji*), encompassing organisations representing public, private and non-governmental entities (including one of the largest association of business enterprises "LEWIATAN", NCBiR, FNP and the consulting firm PwC), and corresponding to the concept of the quadruple helix.

The main players in R&I policy-making and implementation are described below, and presented in Figure 1. The Parliament as the legislative body and the Cabinet (the Council of Ministers) as the executive shape the relevant national policies, with the President having the right to initiate legislative procedures and accept the new legislations. The Ministry of Development (MR) defines and implements the strategies related to innovativeness and supervises the Polish Agency for Enterprise Development (PARP), supporting enterprises based on funds from the state budget and the EU Structural Funds, and through involvement in international projects, including COSME.

It also oversees the policies and regulations related to the absorption of the EU funds, including instruments related to the support for innovative enterprises and R&D projects and co-ordinates the relevant activities of funding agencies. MR was created in December 2015 by the combination of the former Ministry of Economy (MG) and the Ministry of Infrastructure and Development (MIR). The Ministry of Science and Higher Education (MNiSW) manages the science budget and supervises two key funding agencies: the National Science Centre (NCN), financing basic science projects, and the National Centre for Research and Development (NCBiR), financing applied research and innovative development, including R&D projects of business enterprises. There are some overlaps between the activities of PARP (an agency of MR, focused on support for enterprises) and NCBiR (an agency of MNiSW, focused on applied research projects), related to funding R&I by business enterprises. Several other ministries have dedicated programmes, stimulating innovations and research projects in relevant sectors. Recently, an increasingly important role is played by the Ministry of Treasury, which contributes public funding to RDI activities through a state-owned bank, *Bank Gospodarstwa Krajowego* (BGK), supporting innovative ventures by means of credits and venture capital investments by its VC arm, the National Capital Fund (KFK). The Industrial Development Agency (ARP), an agency of the Ministry of Treasury, which traditionally supported the privatization and reorganization processes of large state-owned enterprises, has in recent years ventured into new areas, including innovative projects (such as e.g. financial support for development of graphene technologies).

The Foundation for Polish Science (FNP) is a non-governmental institution, partly funded from the science budget, the EU Structural Funds and other sources, awarding research grants and scholarships, mostly related to fundamental research. The Polish Academy of Sciences (PAN) manages the National Contact Point for Research Programmes of the European Union (KPK), facilitating the participation of Polish scientists in Horizon 2020 and other programmes.

16 regions (voivodeships) with their Marshall Offices define regional operational programmes for the distribution of the EU Funds, including also R&D-related components, and the regional structure is parallel to the centrally-distributed governance of the national RDI system.

Bodies providing science policy advice include: the Committee for Science Policy (KPN), involved in definition of MNiSW policies and the Committee for Evaluation of Scientific Research Institutions (KEJN), analysing the performance of public sector R&D performers and thus influencing the distribution of institutional funding.

Private-sector business support institutions include: venture capital funds, business incubators, technology parks and business angels associations, and their numbers increased in the recent years thanks to the financing from the EU Structural Funds. Business enterprises form numerous industry chambers and associations, which influence the relevant government policies as they are usually consulted in course of the legislative process.

Formal evaluations accompany many public R&I funding programmes and new policy frameworks, but the efforts are fragmented and cannot be considered a coherent system, with standard procedures, which would ensure a repetitive performance of evaluations at pre-determined time intervals. R&D funding agencies evaluate individual programmes (mid-term and ex-post evaluations, with results publicly available online), and use the outcomes to reshape their details in subsequent editions. Ex-ante evaluations are also a common practice for funding agencies, helping define the scope of intended interventions, even though no legal obligations exist for the use of evaluations when planning the programs. Lists of recent evaluations and analytical reports are publicly shared, but the evaluations of individual R&I programmes do not offer directly comparable information. Most of evaluation projects were carried out by external consulting firms to assure the transparency and the reliability of findings.

The government commissioned formal, large-scale evaluations of operational programmes, drawing lessons learned from the 2007-2013 perspective of EU Structural Funds and preparing for the 2014-2020 programmes. All of the newly designed operational programmes on the national and regional levels were subject to ex-ante evaluations and extensive stakeholder consultations, and the major RDI funding programme, the Operational Programme Smart Growth (POIR) was preceded by an extensive, evidence-based diagnosis of the national system of innovations.

The ex-ante screening of proposed legal acts and policy documents is a standard element of the Polish legal framework, and includes: inter-ministerial consultations, consultations with external stakeholders (including also individual citizens through an online platform), and compulsory regulatory impact analyses.

The government uses macroeconomic modelling to assess and forecast the economic growth in relation to policy interventions supported by the EU Structural Funds. The models used include MAMoR, EUImpactMod and HERMIN, but none of these models uses specific R&I-related variables. The Main Statistical Office (GUS) implemented an online system - STRATEG, presenting output indicators used to evaluate public policies, including in the area of R&I.

1.2.3 Research performers

The figure 1 presents an overview of Poland's research and innovation system, outlining its main actors. The R&D performers include: Public Higher Education Institutions (PHEIs, incorporating teaching, research and technology transfer in their missions), Private Higher Education Institutions (focused mostly on education not research, with majority operating in fields of socio-economic sciences and humanities), Public Research Organisations (PROs) focusing on specific areas of applied research, the large national research institution Polish Academy of Sciences (PAN), engaged mostly in fundamental research, and business enterprises. PHEIs combine teaching with research and co-operation with stakeholders, including business enterprises.

They commercialize research outcomes through technology transfer offices and special purpose companies, intended to act as holding companies for academic spin-offs. PROs can in turn establish scientific and industrial centres, nurturing linkages between research institutes and business enterprises.

In 2013, 215 Higher Education Institutions incurred expenditures on R&D, with 108 public and 107 private HEIs, and the public universities invested 13.33 times more in R&D than their private counterparts (GUS, 2015a). The expenditures of PHEIs were also 1.55 times higher than the overall R&D expenditures of 118 PROs, and 3 times higher than the expenditures of 70 institutes of the Polish Academy of Sciences (GUS, 2015a). PHEIs spent 69% of R&D funds on fundamental research and 31% of applied research and development, PAN – 82% on fundamental research, 18% on applied R&D, while PROs presented a different focus, with only 27% invested in basic research and 73% spent on practically-oriented efforts. Still, PROs' co-operation with business enterprises was relatively limited as only 8% of their R&D budgets were funded by companies (GUS, 2015a).

PHEIs reported in 2013 altogether 63,045 R&D employees, PROs – 10,164 employees and PAN – 4,921 employees (GUS, 2015a), so the average expenditures on R&D per capita at PHEIs are substantially lower than at PROs and PAN, but university researchers have also teaching responsibilities.

2,467 business enterprises with 30,250 R&D employees declared R&D activities in 2013, and 45.76% of BERD was funded by enterprises with foreign capital (including multinationals). The flourishing technology start-up scene in Poland is not adequately represented in official R&D statistics, with only 791 business enterprises employing 9 or less persons having submitted R&D questionnaires in 2013 (GUS, 2015a).

A report prepared for the largest start-up association in Poland presented data about 2,432 active start-ups, and results of a survey of 423 start-up firms, with majority located in the cities of Warsaw, Cracow and Wroclaw (Skala et al., 2015: 12).

Over 60% of these firms are funded exclusively by the private capital provided by their founders (Skala et al., 2015: 8) and 15% established by scientists, either PhD holders or doctoral students (Skala et al., 2015: 35). Well over 1,000 start-ups benefited from support measures co-funded from the EU Structural Funds in 2007-2013, particularly newly established ICT and biotech companies, but many of these firms did not report R&D expenditures and thus were omitted in national R&D statistics.

Annex 3 lists main research performers, with companies spending the highest R&D budgets (based on the latest available data for 2011, comp. Baczko et al., 2012) and public R&I organisations with the largest counts of publications indexed in Elsevier Scopus database (data for 2013-2014). Interestingly, out of 20 companies spending annually on R&D €5.4m or more (14 domestic companies and 6 subsidiaries of international firms), only 2 were included in the 2012 EU Industrial R&D Investment Scoreboard, even though this EC-endorsed list of 1,000 EU companies with the highest R&D intensity was supposed to include companies which spent on R&D €5.3m or more in 2011 (JRC-DGRI, 2012).

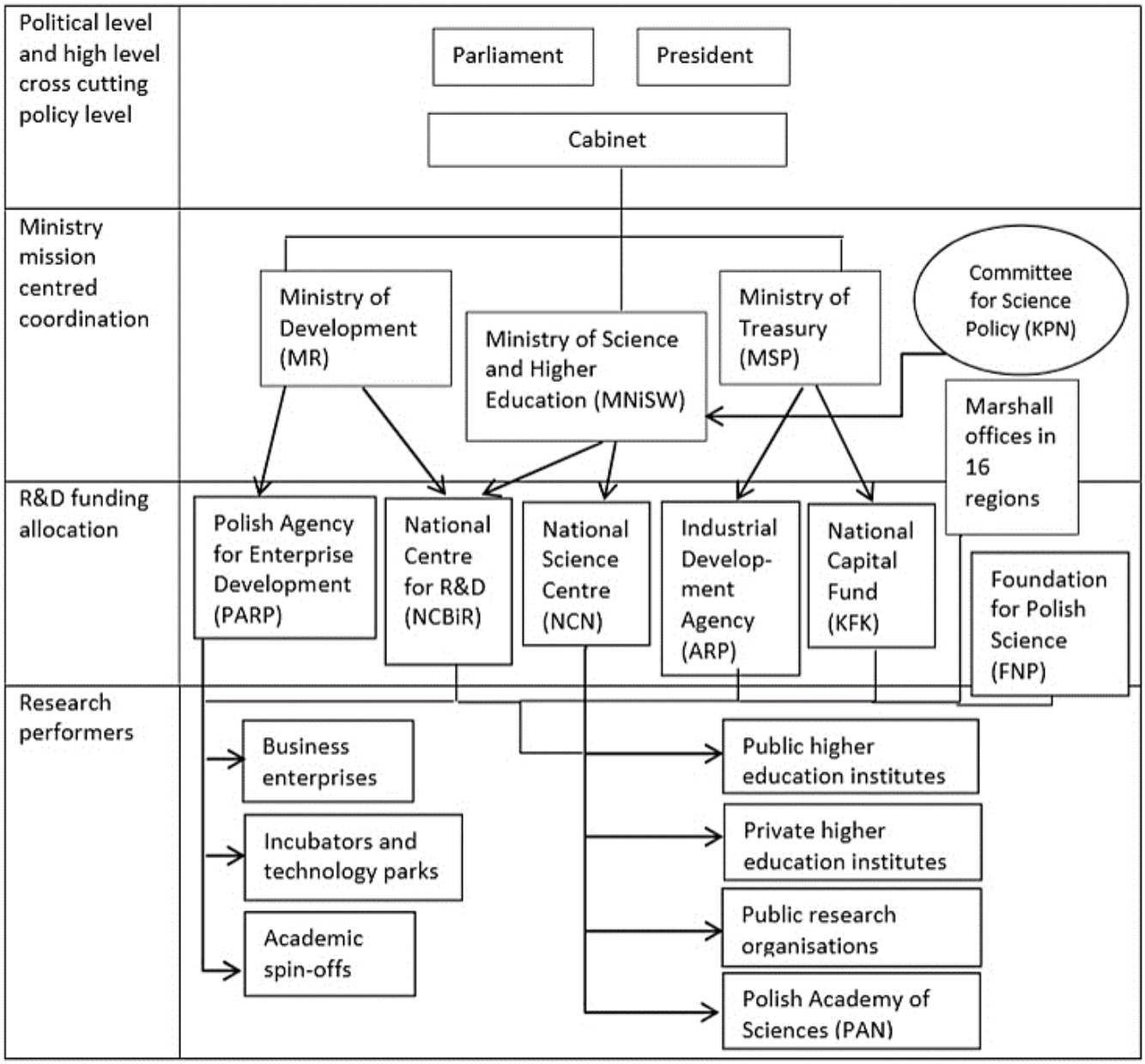

Figure 1 Poland's RDI governance system

2. Recent Developments in R&I Policy and systems

2.1 National R&I strategy

The strategic framework covers research and innovation in an integrated manner, ensuring synergies between R&D and innovative activities, and consists of:

- SIEG (the Strategy for Innovativeness and Efficiency of the Economy), adopted in 2013 as the top-level policy document;
- PRP (the Enterprise Development Programme), adopted in 2014 as implementing programme of SIEG, defining the specific scope of public interventions in R&I area, types of support measures and intended legal reforms;
- KIS (National Smart Specialisations), adopted in 2014 as annex to PRP and further elaborated in 2015, listing 19 strategic areas for R&I, which have the highest economic and innovative potential in the Polish context; the list resulted from comparisons between two large-scale foresight projects (focused on science and industrial technologies), combined with bibliometric data, analysis of publicly funded R&D projects and stakeholder consultations;
- KPB (the National Research Programme), adopted in 2011 as a list of key areas for scientific research (in a form similar to KIS, but preceding the EC initiative on smart specializations, and decomposed into several strategic R&D funding programmes by NCBiR);
- PMDIB (the Polish Roadmap of Research Infrastructures), updated in 2014, consisting of large-scale RI initiatives, recommended for public support;
- POIR (the Operational Programme Smart Growth), a major R&D funding source in the financial perspective 2014-2020, directly linked to other policy documents, including KIS;
- RPOs (Regional Operational Programmes), including dedicated regional funding streams for R&D, based on identified regional smart specializations.

SIEG as the basis for national R&I strategy (with the time frame extending until 2020) includes the Objective 2, which focuses on stimulating innovativeness through the increase in effectiveness of knowledge and work (RM, 2013a: 9), and specific sub-objectives that address the key challenges of the RDI system, including: stimulation of private expenditures on R&D, internationalisation and innovativeness. The quantitative targets, set by SIEG, include: GERD to GDP ratio of 0.93% in 2015 and 1.70% in 2020 (RM, 2013a: 89). The increases of GERD and BERD in 2011-2014 and the substantial, planned expenditures on R&D financed from the EU Structural Funds in 2015-2020 increase the likelihood of meeting the targets, especially as already in 2014, GERD accounted for 0.94% of GDP. According to SIEG, BERD should amount to 0.33% GDP in 2015, and 0.80% in 2020 (RM, 2013a: 89). High-tech and medium-high technology products would build up 35% of sold production in 2015, and 40% in 2020, compared with 31.7% in 2009 (RM, 2013a: 89), high-tech exports would form 6.5% of total Polish exports in 2015, and 8.0% in 2020, while the value for 2009 was 5.7% (RM, 2013a: 89), and share of innovative enterprises would grow to 20.0% in 2015 and 25.0% in 2020, compared with 17.55% of all enterprises in 2009 (RM, 2013a: 89).

PRP implements SIEG's objectives related to business enterprises, including proposals for future policy measures, as well as structural and procedural changes within the public administration sector. PRP attempts to streamline the public support system for enterprises, based on the following principles:

- use of non-refundable grants for highly innovative R&D projects, and revolving financial instruments (such as loans) for the absorption of innovations,
- preference for funding R&D projects related to smart specializations (according to KIS, which formed an annex to PRP, and will be updated in the future based on emerging opportunities and stakeholder consultations),

- preference for financing initiatives of consortia not individual organisations, thus stimulating the bottom-up development of business networks and partnerships between industry and academia,
- modification of application evaluation procedures, de-emphasising paper-based project applications assessed by anonymous reviewers, in favour of interactive presentations of project concepts and collective decisions by panels of domain experts,
- declaration of intent to introduce tax benefits for R&D performers,
- limiting support for the creation of new business clusters, focusing instead of stimulating their development with proportional involvement of private capital,
- strengthening linkages between science and industry, including support for intersectoral mobility of scientists in business enterprises and secondments of company employees in scientific institutions.

Both SIEG and PRP were based on extensive analyses of strengths and weaknesses, and PRP was additionally accompanied by an evaluation, carried out by the World Bank (Kapil et al., 2012). The above-presented documents are integrated, with hierarchically structured system of objectives/priorities, consistent with most of the EU priorities in R&I area, elaborated co-operatively by multiple governmental institutions, and adopted by the Council of Ministers. The high-level documents do not directly address the issues of exploiting opportunities for joint programming or cross-border co-operation in R&I. All of the policy documents were drafted based on multiple evaluations and benchmarking exercises, by drawing from support measures from previous years, in an attempt to develop evidence-based policies.

On the last day of September 2015, the Ministry of Science and Higher Education published the "Programme for the Development of Higher Education and Science for the years of 2015-2030" ("*Program rozwoju szkolnictwa wyższego i nauki na lata 2015-2030*") (MNiSW, 2015c). The programme defines broad directions for the future evolution of the public R&I system, but includes no quantifiable targets, specific activities or allocated funding. It includes among others the following proposals:

- focus on "*quality of results of scientific work (in particular, prestigious publications and valuable implementations) not quantity*" (MNiSW, 2015c: 22) with institutional assessments involving peer-reviews and in-depth analysis of selected, key achievements instead of the present bibliometric analyses of all publications;
- reduction of administrative burdens of scientists (MNiSW, 2015c: 26);
- evaluation of the proposal reviewing practices at government R&D funding agencies and elimination of conflicts of interest (MNiSW, 2015c: 24);
- preference for permanent not temporary employment (tenures) for university researchers with PhDs (MNiSW, 2015c: 12);
- obligation to carry out the post-doctoral (*habilitation*) procedures in organisations other than the researcher's place of employment (MNiSW, 2015c: 14);
- proposal to establish a dedicated government agency, consolidating efforts related to the internationalisation of science and promotion of mobility of researchers (MNiSW, 21);
- strengthening of funding streams for R&D projects translating results of fundamental research into technology development (MNiSW, 2015c: 34);
- introduction of R&D tax exemptions for business enterprises and patent box-type incentives (MNiSW, 2015c: 35).

The document outlines a substantial number of foreseen changes, but fails to present details of the proposals, and many of the indicated elements seem not sufficiently rooted in the analysis of empirical data, existing legislation and financial realities, affecting Poland's R&I system. The internal inconsistencies might be attributed to the eclectic character of the document, compiling inputs submitted by several advisory teams (MNiSW, 2015c: 5). It also contains numerous problematic elements, e.g. ideas for alternative approaches to the institutional evaluation of scientific organisations are inconsistent with the ongoing, parallel legislative efforts of the Ministry, concerning the amendments of criteria for institutional evaluation, which would be implemented by 2017. The programme proposes also the identification and pursuit of national research specialisations, as if its authors were not aware of the existence and contents of the national smart specialisation strategy (MNiSW, 2015c: 26-27). Importantly, the document has no formal legal status, had been prepared without stakeholder consultations (including other ministries and representatives of scientific institutions), even though such consultations are legally required for policy documents, and was published by the Ministry on its website merely 25 days before the parliamentary elections, which brought about major changes to the Polish political scene, so its overall impact is expected to be insignificant.

2.2 R&I policy initiatives

The main R&I policy initiatives from 2013-2015, related to laws and other regulations, are listed below:

- The Council of Ministers adopted policy documents PRP, KIS, POIR and RPOs, as described earlier in the chapter (2014), and the final versions of POIR and RPOs were accepted by the EC (2015).
- The Parliament amended the Act on Public Procurement, which simplified purchasing procedures at PHEIs and PROs, by freeing them from standard public procurement routes if the order is used for R&D purposes and its value is lower than €207k (the level was €14k before). The upper limit for all purchases that do not require public tenders was also raised from €14k to €30k. Public procurement regulations no longer apply to research services, results of which would be openly shared with the public. Moreover, public procurement results can be easily nullified if the organisation does not receive R&D funds, which were allocated to finance the order in question (2014).
- The Ministry of Administration and Digitization published draft guidelines of the planned Act on Reuse of Public Sector Information, ensuring that contents generated by government institutions are available in Open Access and opened the guidelines for public consultations (2014). The act will not affect information generated by PHEIs or PROs. This is a major change from the previous version of the guidelines, which were published in December 2012 and widely criticized due to multiple legal shortcomings, but at the same time were more aligned with the Commission Recommendation from 17 July 2012 on access to and preservation of scientific information (2012/417/UE). The Ministry of Science and Higher Education prepared in 2015 non-binding recommendations concerning open access to research data and publications (MNiSW, 2015b) and initiated public consultations of the document.

The Parliament amended the Act on Higher Education (2014), in reaction to the disappointments with the slow uptake of the academic technology transfer. Ownership of IPRs to academic inventions can be assigned to their individual creators, if the employing institution decides not to commercialize an invention within 3 months following its disclosure by inventors to the institution. In order to transfer the IPRs, academic inventors need to sign a standardized agreement with their employer and pay a symbolic fee. The amendment presents an exception from the general rule related to inventions developed by employees, since in the Polish legal system, the rights traditionalllong to employers.

The proposed regulation was expected to stimulate the commercialisation of research results by offering direct financial motivation to scientists and simplifying technology transfer processes, which are currently complicated due to the applicability of regulations concerning public finance. Many institutions perceive the new regulation as a major disruption in their operations, depriving them of the intellectual property and contradicting the science and higher education reforms from previous years. The move could increase the involvement of scientists and stimulate the science-industry co-operation, but the employing institutions can easily block aspirations of scientists-inventors (as the possibility of transferring IPRs is contingent upon the decision of PHEI). Furthermore, the regulation is not consistent with R&I policy directions and multiple support measures, which highlighted the importance of institutional control of IPRs by strengthening technology transfer offices and establishing the positions of innovation brokers at PHEIs.

- The Parliament amended the Act on Principles of Financing Science (2015). It facilitates the planning of investments in research infrastructures, as projects included in the national roadmap PMDIB are classified as "Strategic Research Infrastructures" with prioritized access to funding. The Act introduced some clarifications regarding the algorithm, which determines the levels of institutional funding. It also elaborated the rules of financing international R&D projects and projects, in which Polish researchers benefit from foreign research infrastructures.
- Scientific journals ensuring open access to publications can benefit from public funding, as defined in the Act. Finally, the amendment contributes to the establishment of a central IT system, aggregating data about R&D activities in Poland by expanding the scope of the existing system POL-on, which originally has only collected data about PHEIs, but after the amendments, it started covering also scientific publications, citations, data on PROs and other datasets useful for R&I monitoring and evaluation.
- The government drafted numerous strategic documents, with relevance to R&I policy, including: the programme for development of space technologies and use of satellite systems (capitalizing on Poland's accession to ESA and increased private investment in the sector) (2014), the "Package for Humanities" (reconfirming public support for humanities and social sciences) (2014), the "Pact for Horizon 2020" (voluntary agreement of MNiSW with interested PHEIs and PROs, ensuring additional organizational support for research teams applying for funding and implementing Horizon 2020 projects, and offering co-funding to successful applicants) (2014), and the programme for protection of copyrights (prepared by the Ministry of Culture and National Heritage, including planned activities to promote the IPR management) (2014).
- Changes to the rules of awarding institutional funding defined by an ordinance of the Minister of Science and Higher Education (2014) can be regarded as a powerful performance-enhancing measure, likely to raise scientific excellence. From 2015 on, institutional funding will only be allocated based on the most recent institutional evaluation, thus amending the past rules, which were taking into account also the outcomes of previous evaluations.

The Ministry of Science and Higher Education published a draft ordinance concerning the amendment of criteria and modalities for evaluation of scientific organisations, which determine the institutional funding (2015). According to MNiSW, the new criteria were intended to ensure an increased focus on innovations, international co-operation and open science, but in fact, the amendments contain only minor tweaks compared to the previous regulation, which had already governed the institutional evaluation of 2013. MNiSW promoted the draft as a disruptive change to the institutional funding system, but the Ministry actually used the already proven criteria and drew some lessons learned from the procedural problems, which resulted from the previous evaluation.

Nevertheless, the underlying logic of the evaluation, desirable and thus promoted types of activities and outcomes, and evaluation methods remained the same as before. The draft was subject to a broad consultation process, which seems important as in the past, MNiSW encountered strong criticism expressed by many scientific organisations, as the 2013 evaluation reshuffled the scienancing system by linking the institutional funding to performance, and the social acceptance for the minor amendments introduced in 2015 might legitimize the overall, outcome-oriented approach in the science system. The next institutional evaluation is scheduled for 2017.

- The Ministry of Science and Higher Education adopted an ordinance, concerning the modalities for offering public aid by the National Science Centre, NCN (2015). NCN is allowed to directly offer public aid, i.e. support fundamental research projects carried out by business enterprises. The support will encompass direct funding for R&D and financing internships by academic researchers, involved in projects conducted by business enterprises. So far, public aid for R&D in the private sector has only been distributed by NCBiR and PARP and focused on applied R&D, thus restricting potential science-industry co-operation.
- The Parliament adopted in September 2015 the Act on Amendments of Some Acts with respect to the Support for Innovativeness, based on a proposal submitted by the President. The Act includes multiple pro-innovativeness amendments of other regulations, addressing challenges identified in operations of business enterprises, financial investors and scientific organisations. The initial version of the Act included substantial tax exemptions for R&D performers, but they were eliminated in the subsequent parliamentary work.
- The Act introduces the definition of R&D efforts into the Polish tax system, allowing tax payers to classify parts of their R&D expenditures as tax-deductible costs starting from 2016 and obliging them to account for these expenditures in their financial statements. In this way, private sector organisations receive an important incentive to declare R&D expenditures, as opposed to the past regulations, which only allowed to deduct product development expenditures from related product revenues if the R&D efforts were successful, and did not considered research expenditures as deductible expenses, thus disincentivizing most forms of R&D. Furthermore, the Act facilitates the employment of scientists with foreign qualifications and international research experiences, allowing them to participate in formal scientific procedures such as promoting or reviewing doctoral theses and habilitations, and streamlines the procedures for issuing work permits for foreign graduates of Polish or EU universities as well as foreigners undertaking doctoral studies in Poland. Investors in innovative start-ups will enjoy time-limited tax reliefs, allowing them to contribute intangible assets (with the exception of software copyrights) or provide financial capital to the companies in 2016 and 2017 without the need to pay taxes on profits from the subsequent disposal of the shares or public listing of the company.

Support measures, relevant for R&I system, which were introduced in 2013-2015, are summarized in the following list:

- NCBiR launched support programmes "DEMONSTRATOR+" (support for development of technology demonstrators or pilot installations by business enterprises) and "BRIdge" (a framework of support measures, developed as public-private partnership with investment funds and consulting firms, targeting innovative ideas and projects developed by scientists, at different stages of innovation cycle) (2013).
- PARP started offering "large innovation voucher" - vouchers for SMEs, covering the costs of contracted R&D services, delivered by scientific organisations (2013). The vouchers were used by 46 firms in 2013 and 68 firms in 2014, with an average voucher value of about €10k.
- The government introduced a framework for R&I support, including PRP and KIS (2014) and prepared draft operational programmes, including POIR (2014).

- MNISW finished an update of the Polish Roadmap for Research Infrastructures (PMDIB), consisting of 53 projects, which consolidate the scientific potential in specific fields of research and rationalise the management of RI (2014).
- The Council of Ministers amended the rules for "Programme for the support of investments of considerable importance for Polish economy for years 2011-2020", which offers grants to large investors, mostly FDIs (2014). The amendments include incentives for R&D investments, and investors from priority sectors (automotive, electronics, aviation, biotechnology, modern sers).
- NCBiR jointly with NCN initiated programmes TANGO (supporting the follow-up applied research based on results from fundamental research projects, funded previously by NCN), "Social innovations" ("*Innowacje Społeczne*"), GEKON (environmental technologies), RID (transport technologies), CuBR (non-ferrous metals) and INNOMED (innovative medicine) (2014).
- NCBiR established the framework for "sectoral programmes", in which R&D funding is allocated to research agendas defined by a representation of a specific industry, committing to supply private co-funding (2014).
- NCBiR introduced project "SIMS" ("Science Infrastructure Management Support"), targeting beneficiaries of support measures from 2007-2013, used to establish research infrastructures (2014). SIMS was intended to stimulate the commercial use of RIs, introduction of good management practices and international collaboration related to the infrastructures by means of training, consulting services and internships at foreign institutions.
- MNiSW started offering a redesigned "Grants for grants" ("*Granty na granty*") instrument, co-funding the preparation of application by prospective project co-ordinators in Horizon 2020 and other international R&I programmes.
- The acceptance of POIR by the EC spurred a number of new or modified support measures, offered by government funding agencies, and standardized the R&I support system, with clearly differentiated support measures, similar project selection criteria, cost eligibility criteria and application rules (2015). Most measures are similar to previously available instruments, but have been streamlined, with proposal evaluation processes better targeting innovativeness and commercial potential of projects. These measures include:
    - "Fast track" ("*Szybka ścieżka*") - POIR support measure no. 1.1.1 (NCBiR) for R&D projects by business enterprises, with a permanently open call for proposals and proposal evaluation within 60 days from the submission;
    - "DEMONSTRATOR+" - POIR support measure no. 1.1.2 (NCBiR), targeting the development of pilot installations or proof-of-concept activities;
    - "Sectoral programmes" - POIR support measure no. 1.2 (NCBiR), with programs launched: INNOMED (medical technologies), INNOLOT (aviation), accepted for detailed funding negotiations: INNOCHEM (chemical engineering), INNOTEXTILE (technologically advanced textiles), InnoSBZ (unmanned aerial vehicles), and 10 proposed programs returned to applicants to be improved and submitted for further negotiations;
    - Support for investments in research infrastructures by companies – POIR support measure no. 2.1 (MR);
    - "Open innovations" – POIR support measure no. 2.2 (ARP), with establishment of a database of available technologies and experts, match-making activities and financial support for technology transfers;
    - "Innovation voucher" - POIR support measure no. 2.3.2 (PARP), offering vouchers for SMEs covering the costs of R&D services by scientific organisations;

- "Internationalisation of key clusters" - POIR support measure no. 2.3.3 (PARP), available for the international expansion of innovative clusters, selected in a nation-wide competition;
- „Protection of industrial property" - POIR support measure no. 2.3.4 (PARP), financing international IPR protection and commercialization at SMEs;
- Support for innovations combined with venture capital funding – POIR support measure no. 1.3 (NCBiR) and 3.1 (implementing institutions selected in an open competition);
- "Research for the market" ("*Badania na rynek*") - POIR support measure no. 3.2.1 (PARP), targeting R&I projects, which involve an implementation of innovations developed or licensed by business enterprises that contribute to the launch of new products or services;
- Financial instruments including technological credit (POIR support measure no. 3.2.2, BGK) and guarantees for innovative companies (POIR support measure no. 3.2.3);
- "Polish technological bridges" (*"Polskie mosty technologiczne"*) – POIR support measure no. 3.3.1 (MR), acceleration programs for selected high-tech companies in international locations, including Silicon Valley;
- Strategic, national and regional R&D programs, consistent with smart specialisations and responding to the needs of business enterprises – POIR support measures no. 4.1.1 and 4.1.2 (NCBiR)
- "Virtual Research Institutes" ("*Wirtualne Instytuty Badawcze"*) – POIR support measure 4.1.3 (NCBiR) – R&D projects complementing the Horizon 2020 Twinning initiative;
- "Applied projects" (*"Projekty aplikacyjne"*) – POIR support measure 4.1.4 (NCBiR) – applied R&D projects carried out by consortia of scientific and business organisations;
- "Development of modern research infrastructures for the science sector" – POIR support measure no. 4.2 (OPI), financing research infrastructures included in the national roadmap PMDIB;
- International research agendas – POIR support measure 4.3 (FNP) – complementing the Horizon 2020 "Teaming for excellence" initiative by funding the leading internationally oriented R&D agendas;
- Improving the R&D personnel potential – POIR support measure 4.4 (FNP) – with several dedicated support measures promoting research excellence, with ERC-type grants to establish new research teams, support for Polish citizens relocating back to Poland after an extended period of research abroad, and internships of scientists in business enterprises, based on proven frameworks established by FNP in previous years.

- R&I support measures were also included in other operational programmes, with funding for regional R&I and RI projects, consistent with regional smart specialisations, available from the Operational Programme Development of the Eastern Poland (PORPW) and 16 Regional Operational Programmes (RPOs). A dedicated measure "*E-Pionier*" from the Operational Programme Digital Poland (POPC) will rely on the model of pre-commercial procurement to stimulate the development of software solutions that address specific, identified public problems.
- PARP launched new edition of its instrument "Support for getting a grant" ("*Wsparcie na uzyskanie grantu*"), financing the preparation of project applications by SMEs, applying for funding from Horizon 2020 and other R&I-related, international programmes (2015).

- NCN established a new programme "POLONEZ" (2015), targeting foreign scientists planning to conduct R&D projects in Poland and offering them monthly salaries of €4,050, co-funded from Horizon 2020.
- MNiSW jointly with the Ministry of Labour and Social Policy launched a programme "*MALUCH na uczelni*" ("TODDLER at the university"), supporting the establishment of nurseries at 43 PHEIs, which will accommodate the children of students, doctoral students and lecturers and thus improve their work-life balance.
- MNiSW introduced significant changes to the "National Programme for the Development of Humanities" ("*Narodowy Program Rozwoju Humanistyki*"), modifying its objectives and modalities, and increasing its budget (2015). The redesigned programme focuses on interdisciplinary research and internationalisation, including support for foreign publications of Polish research. The changes were triggered by "the Round Table of Humanities" from 2014, a ministerial dialogue with representatives of these scientific disciplines.
- NCBiR introduced "*BRIdge Alfa*" (2015), with 10 dedicated seed funds, combining private funding (offered by 10 experienced private partners, VCs and investment funds) with public co-funding (based on POIR, support measure no. 1.3.1). The programme focuses on the incubation of early-stage ideas and projects by academic researchers, for which a proof-of-concept is needed, and which conclude with the establishment of academic spin-offs. Individual investment partners undertake outreach activities by liaising with scientists and offering specialist advice, and co-funding for the most promising projects will be awarded based on decisions by the programme's investment committee. BRIdge Alfa complements other BRIdge programmes: BRIdge VC, focused on accelerating the growth of successful, innovative companies (including earlier beneficiaries of BRIdge Alfa; funding based on POIR, support measure no. 1.3.2), and BRIdge Mentor, offering advice to scientists and inventors at a stage preceding the BRIdge Alfa engagement.
- ARP (the Industrial Development Agency) initiated its direct involvement in R&I support (2015) as a sovereign investment fund, targeting innovative companies, and a technology transfer clearing house.

Apart from R&I policies, there are also complementary policies related to education, product and service markets, financial and labour markets, entrepreneurship, spatial planning and infrastructure, all of which have the potential of further strengthening the innovativeness. Separate plans exist for higher education and lifelong training, but they benefit from inter-linkages with R&I policies. Activities related to technological innovations are also intertwined with R&D support, and their implementation is co-ordinated by the same agencies, while non-technological innovations often require a different approach.

Investments in research infrastructures are covered by the R&I policies and strategies, with the national roadmap (PMDIB), dedicated support measures based on the state budget and the EU Structural Funds (both on national and regional level), and co-ordination of RI investments with national and/or regional smart specialisations.

Fundamental research is supported through different modalities than applied R&D, ensuring continuous development of the necessary knowledge base. A potential limitation is the excessive focus on applied R&D, demonstrated by the imbalance in allocated funding and availability support measures, while some fundamental research initiatives might require proportionally higher budgets. Most of applied R&D funding is distributed directly to business enterprises, and academic researchers might find it difficult to fund their practically-oriented projects. Nevertheless, project evaluation criteria of R&D funding agencies NCN and NCBiR facilitate support for frontier science in projects focused on breakthrough ideas and novel scientific approaches.

This type of ambitious research has been Poland's traditional strength in empirical disciplines, whereas commercialization of the revolutionary findings proved more challenging.

2.2.1 Evaluations, consultations, foresight exercises

The government commissioned formal, large scale evaluations of operational programmes, drawing lessons learned from the 2007-2013 perspective of the EU Structural Funds and preparing for the 2014-2020 programmes. Findings from these projects were used when drafting the new programmes, and removal of certain bureaucratic obstacles in funding agencies. All of the newly designed operational programmes on the national and regional levels were subject to ex-ante evaluations and extensive stakeholder consultations, and the major R&I funding programme, the Operational Programme Smart Growth (POIR) was preceded by an extensive, evidence-based diagnosis of the national system of innovations and broad consultations with stakeholders. As part of the preparations for the 2014-2020 perspective, the government commissioned also detailed studies, intended to facilitate the design of new support measures.

The evaluations conducted in 2014 included a comprehensive analysis of R&I support measures available in the 2007-2013 financial perspective (OPI-Millward Brown, 2014). The study indicated problems with practical uses of the outcomes of many R&D projects, especially when the projects had just been completed before the evaluation study, and challenges related to sustainable funding research infrastructures acquired by scientific organisations. The most promising outcomes were identified for R&D projects carried out by business enterprises (applied research and technology development). The study offered also important recommendations regarding the evaluation of project applications (criteria and procedures).

Another, complementary study concerned the influence of the EU funding on the innovativeness of business enterprises (WYG PSDB, 2014a). It demonstrated positive impact of the funding on beneficiary firms, but also negative tendencies among companies that did not use the funding, thus contributing to a possible conclusion that EU Structural Funds might have contributed to crowding out private funding for R&D and decrease the propensity of companies to innovate. The study highlighted numerous barriers to innovativeness of business enterprises, identified by the surveyed companies, as well as good practices. In parallel, NCBiR commissioned the consulting company PwC to analyse the private co-funding for R&D projects in order to demonstrate the scale of investments stimulated by NCBiR-supported projects in comparison with the overall BERD in Poland (PwC, 2014).

An interesting example of program evaluation is a study commissioned by NCBiR to evaluate "DEMONSTRATOR+", a support measure available for business enterprises, focused on the development of proof-of-concept or pilot installation, resulting from applied R&D efforts (Taylor Economics, 2014). The study analysed individual co-funded projects, evaluating their innovativeness, commercial outcomes, implementation problems and risk factors, and the publicly available report includes an extensive analysis, which supported further modifications of the support measure, currently available in POIR.

In 2015, the Ministry of Science and Higher Education commissioned a comprehensive evaluation of six R&I support measures that were directly implemented by the Ministry and not by the R&D funding agencies, including the "KNOW" program, the National Program for the Development of Humanities and the Incubator of Innovativeness.

Lists of evaluations and analytical reports are presented online[8], and a centrally maintained database of evaluation projects on regional and national levels, with links to evaluation reports, is available on a government website[9]. Details of relevant evaluations and other reports are provided in Annex 5.

Apart from programme evaluations, PARP carries out annual surveys "Barometer of innovativeness", based on an enterprise panel consisting of beneficiaries of the EU Structural Funds for R&I. NCBiR surveys their beneficiaries, collecting detailed data on their R&D expenditures and these activities are interpreted as major source of BERD increase in 2012, as many companies had their first opportunity to better understand what could be interpreted as R&D spending and how to formally report the spending in order to be included in national GERD statistics.

The Ministry of Infrastructure and Development contracted the World Bank to evaluate smart specialisation strategies, prepared by regions, and the Ministry of Economy worked with the World Bank on monitoring smart specialisation strategies. Poland decided in 2015 to benefit from the EC's Policy Support Facility in the area of R&I policies. The Polish Patent Office commissioned in 2015 a study of patent holders, intended to better understand the corporate propensity to patent and barriers to patenting and effective commercialisation of innovations in the Polish institutional context. PARP commissioned a report outlining possible ways of supporting the industrial design and its importance for the innovativeness of the economy (Realizacja Sp. z o.o., 2014). In 2015, the consulting firm McKinsey & Company published an extensive report outlining possible future developments of Poland's economy, recommending focus on process manufacturing (as opposed to technology-intensive industries) and highlighting the need to increase the R&D intensity (McKinsey, 2015). The National Audit Office (NIK) presented the results of an evaluation of public research institutes (NIK, 2015), highlighting their relatively low revenues from the commercialisation of innovations, limited counts of international patents, and focus on routine analytical work contracted by third parties and scientific publications. NIK pointed to the widening generation gap at PROs, lack of long-term R&D directions and insufficient linkages to the industry. An association of new technology-based companies "Startup Poland" published results of a nation-wide start-up survey (Skala et al., 2015), profiling 17% of the Polish start-up population.

Extensive stakeholder consultations preceded various legal initiatives, including: the amendments of the Act on Higher Education (2014) and the Act on Principles of Financing Science (2015), as well as planned modifications of institutional evaluations, support for Polish applicants in Horizon 2020, and the role of humanities in the science budget (comp. chapter 2.2). The work on smart specialisations on national and regional levels has also triggered stakeholder dialogues, as described in the chapter 2.4.

2.3 European Semester 2014 and 2015

NRP 2014-2015, adopted in April 2014 and covering two consecutive years, emphasized the importance of increasing the R&D expenditures to fuel the economic growth (RM, 2014a: 23) and projects the GERD to GDP rations as 0.93% in 2014 and 1.02% in 2015 (RM, 2014a: ome activities foreseen for 2014-2015 could not really be considered reform plans, as they refer to activities, which were initiated before NRP was drafted:

[8] http://www.ncbir.pl/o-centrum/ewaluacja/ (NCBiR), http://www.ncn.gov.pl/finansowanie-nauki/statystyki (NCN) and http://badania.parp.gov.pl/index/index/1757 (PARP), access date: September 2015.
[9] www.ewaluacja.gov.pl/WYNIKI/Strony/Wyniki_badan.aspx, access date: September 2015.

- establishment of a support system for business enterprises, distributing the EU Structural funds (RM, 2014a: 27), and continuity of operations of KSI (National Innovation Network) and KSU (National System of Services) - networks of publicly co-funded consultancy services providers (RM, 2014a: 28-29),
- implementation of R&D funding programmes by NCBiR and MNiSW in accordance with the previously agreed budgets (RM, 2014b: 31, 35-36), a wide range of support programmes by NFOŚiGW, targeting environmental and energy innovations (RM, 2014a: 42), and programmes based on the EU Structural Funds in 2014-2020.

New activities from NRP 2014-2015 relevant to the RDI area were:

1) an update of the RI roadmap PMDIB and implementation of legal changes, facilitating the public funding for PMDIB projects (RM, 2014a: 28),
2) implementation of the updated "Programme for the support of investments of considerable importance for the Polish economy for 2011-2020", intended to attract R&D-intensive FDIs, with specific funding allocated by the Ministry of Economy (currently: the Ministry of Economic Development) (RM, 2014a: 31-32),
3) an update and follow-up implementation activities for the industrial technology foresight project "InSight 2030" by Ministry of Economy, contributing towards an elaboration of the list of national smart specializations (RM, 2014a: 32),
4) establishment of "the Polish low-emissions economy and green technologies platform, allowing for the identification of the environmental protection technologies available in the country" by Ministry of Environment using World Bank funding (RM, 2014a: 32),
5) establishment of a system for cyclical evaluation of scientific and technological capacity, as a follow up of an earlier national scientific foresight programme, with website and dedicated reports to be launched in 2014 (RM, 2014a: 33),
6) carrying out a public survey of non-technological innovations by the Ministry of Culture and National Heritage among entities operating in the field of culture and creative industries to facilitate planning for targeted support instruments in the future (RM, 2014a: 33),
7) establishment of the "Register of [HR] Development Services" by PARP intended to facilitate training decisions in business enterprises, to be launched in 2015 (RM, 2014a: 34-35),
8) an update to the financial scheme, funding industry-science RDI collaboration "innovation voucher" in 2015 (RM, 2014a: 34).

Most of these activities (with the exception of activity no. 4) were indeed implemented in 2014 and 2015. The Programme came short of declaring any specific activities related to the introduction of R&D tax reliefs, which were recommended in CSRs for Poland in 2013 and 2014. It referred to the opinions of social partners, who had supported this fiscal mechanism in the course of public consultations of government policy documents, but explained that "the consequences of the implementation thereof are still being analysed and no decision has yet been taken as to the final form of the said mechanism" (NRP, 2014a: 24). While the government successfully delivered on most of the promises from NPRs in the area of R&I, there was a demonstrable inactivity in the area of tax policies for RDI.

NRP 2015-2016, adopted in April 2015, highlighted the importance of the Operational Programme Smart Growth as a new source of funding, expected to increase private R&D investments (RM, 2015a: 20). The Programme outlined several activities, which had been implemented before the NRP was prepared, and some were actually due to expire in 2015:

- maintaining the system of services dedicated for business enterprises, related to innovations (RM, 2015a: 24,)
- financing research infrastructures based on specific legal modalities, elaborated in 2014 with the amendment of the Act on the Principles of Financing Science (RM, 2015a: 25),
- offerif existing R&I support programmes by NCBiR (RM, 2015a: 26), PARP (RM, 2015a: 29-30) and MNiSW (RM, 2015a: 30-31),
- continuous implementation of the "Programme for the support of investments of considerable importance for the Polish economy for 2011-2020" by Ministry of Development (RM, 2015a: 27-28).

Even though the NRP covers two years of 2015 and 2016, all new activities related to R&I are scheduled for 2015 only, and include:

- launch of credits for technological innovations, offered by BGK based on the EU Structural Funds (POIR), scheduled for Q3 2015 but requiring amendments of legal regulations (RM, 2015a: 24) and not implemented in a timely manner in 2015;
- support measure for the "Key National Clusters", offered by PARP based on POIR (RM, 2015a: 24-25);
- development of sectoral programs by NCBiR, with two programs – INNOLOT and INNOMED – prepared already before 2015 and more programs declared to be launched in Q3 2015 (RM, 2015a: 27), but due to planning delays their launch was postponed;
- introduction of a monitoring mechanism of smart specialisations (KIS) including the establishment of the Economic Observatory by the Ministry of Economic Development, scheduled for Q3 2015 (RM, 2015a: 28-29) and yet not fully implemented;
- development of a system for "cyclical evaluation of scientific and technological capacity" by Ministry of Science and Higher Education (RM, 2015a: 29), based on the outcomes of an earlier, large-scale scientific foresight, which might already be outdated in 2015 and the "system" established in 2015 turned out to be a web portal aggregating R&I indicators, available also from other sources.

The R&I-related actions outlined in NRP 2015-2016 do not seem sufficiently ambitious, and the government has probably shifted its focus to rely mostly on the EU Structural Funds and s measures financed from POIR.

The Country Report prepared by the European Commission for the 2015 European Semester identified key challenges for the Polish R&I system, including low R&D expenditures in general and by private sector (EC, 2015: 23), unsatisfactory internationalisation and limited scientific excellence (EC, 2015: 23-24). At the same time, the EC presented a moderately positive assessment of measures implemented and/or planned by the Polish government (EC, 2015: 23-24). It saw "limited progress" in establishing science-industry linkages and "some progress" in establishing a comprehensive R&I support system with instruments targeting different stages of the innovation cycle (EC, 2015: 24). It was however very critical of the "no progress" in the area of indirect support for R&I, negatively assessing the existing tax incentives, which promote external sourcing of technologies not R&D (EC, 2015: 24). Importantly, Poland's NRPs for 2014-2015 and 2015-2016 remained silent about any R&D tax measures, even though in previous years, the government was promising to implement them as soon as Poland is removed from the excessive deficit procedure.

The Country Specific Recommendations (CSR) adopted by the Council of the European Union for Poland in 2014 pointed out that "a low share of growth-enhancing expenditure (education, research and innovation) hampers long-term growth prospects" (CEU, 2014: 4). The supporting assessment document, prepared by the European Commission, offers more insights into the updated interpretation of Poland's progress in R&I area.

The Council appreciated that in 2007-2012, the R&D intensity rose "at an impressive average growth rate of 9.7%, slightly higher than 8.3% average annual growth required to reach the ambitious Polish target of 1.7%", but "reaching the target will not be possible without a significantly bigger role for the business sector in the R&D system" (EC, 2014: 34).

It emphasized that "Poland has steadily improved its external competitiveness, and further improvement is likely over the near term" (EC, 2014: 20), but based on an analysis of export-related data from 2002-2012, the country still "lacked comparative advantage in medium-high and high technology goods, reflecting low R&D spending in the private sector, heavy reliance on technology absorption and low intensity of in-house innovation among exporters" (EC, 2014: 21).

The R&I-related recommendations from 2014 included: (1) improving the effectiveness of tax incentives in promoting private sector R&D "as part of the efforts to strengthen the links between research, innovation and industrial policy", and (2) "better target[ing of] existing instruments at the different stages of the innovation cycle" (CEU, 2014: 6).

The recommendation (1) remains unanswered by the Polish government. The existing tax regulations do not really incentivise R&D expenditures. Tax breaks for the purchase of new technologies discourage in-house R&D and are used by a limited number of large enterprises, mostly to lower the costs of ICT systems acquisitions. Incentives for R&D centres concern a very small group of companies, which meet the stringent criteria for registering the R&D centre status. Even though the Enterprise Development Programme (PRP) included vague plans to introduce more comprehensive tax incentives for R&D performers, no legislative drafts were presented by the Ministry of Finance. Lack of sincere interest in addressing this particular CSR can also be inferred from the contents of National Reform Programmes 2014-2015 and 2015-2016, failing to list any relevant activities planned in this area. Moreover, the process related to the adoption of the Act on Amendments of Some Acts with respect to the Support for Innovativeness (2015) revealed the government's refusal to adopt R&D tax breaks, which were included in the initial proposed text of the Act, submitted by the president, as any references to R&D tax exemptions were later removed from the legislative text.

The recommendation (2) emphasises the need for systemic, integrated approach to prioritization and support, so that the entire innovation cycle is considered, from the inception of new ideas to their successful commercialization. Poland used to have multiplicity of dedicated support instruments, but they were offered by several different government agencies and some participants of the national system of innovations did not understand their synergies or complementarities. Nevertheless, the portfolio of instruments comprehensive and covered most elements of the innovation cycle. In recent years, new support instruments were introduced to fill the identified gaps: support for the first implementations of patented technologies (PARP), the internationalization of high-tech enterprises (NCBiR), the establishment of technology transfer companies by PHEIs and PROs (NCBiR), and the support for innovation brokers, acting as agents selling technologies developed by PHEIs (MNiSW). NCBiR launched also two relevant initiatives, addressing gaps in the innovation cycle, related to: the "death valley" between applied research and commercialisation, which requires a demonstration of technological prototypes (programme DEMONSTRATOR+), and the much-desired follow-up research activities related to outcomes of fundamental research projects, which appear as commercially useful (programme TANGO).

In the new financial perspective of 2014-2020, there are further improvements, which will streamline the support for the entire cycle, including differentiated sets of measures for specific sectors (so-called "sectoral programmes").

2.4 National and Regional R&I Strategies on Smart Specialisation

Poland has a list of 20 prioritized R&I areas, dubbed National Smart Specialisations (KIS). KIS was derived from a multi-annual planning process, preceding the EU's initiatives related to smart specialisations. In 2006-2009, MNiSW carried out a large-scale foresight exercise, "*National Foresight Programme Poland 2020*", which was used to develop the strategic directions for scientific research, described in a formal government document KPB (National Research Programme), adopted in 2011 and influencing the design of R&D support, particularly for scientific organisations.

In 2010-2012, MG conducted a complementary project, focusing on technological needs of the business sector, "*Technological Foresight of Industry – Insight 2030*", which helped identify 99 technologies, considered critical for the future competitiveness of domestic companies.

While preparing the Enterprise Development Programme (PRP), MG cross-validated the outcomes of these two foresight studies, combining them with relevant quantitative data (including trends in patenting and use of public support for R&D) to identify technological areas, which have gathered critical mass and could be considered national specialisations. These analytical outcomes were subject to social consultations, shaping the final composition of the KIS, which was adopted by the government as an annex to PRP. The Steering Committee for National Smart Specialisations was established and authorised to continue the work on defining and amending KIS, so that its future changes could result from expert work not government decisions. MG announced an open call for experts to join taskforces established for each identified speciality area, and altogether 476 representatives of science and industry were engaged in the further work on KIS in 2014-2015 (MG, 2015b). The taskforces were tasked with preparing detailed guidelines concerning each particular specialisation. In this way, an extensive document was created, describing R&I areas-specialisations. This precision in describing KIS contents was important, as Poland committed to allocate 98% of the R&I funding covered by POIR to projects, which are consistent with KIS. In the course of the work, another specialisation area was added to the list – creative technologies, encompassing among others multimedia and computer games, based on the identified economic and innovative potential. In March 2015, the Steering Committee adopted the document describing 19 smart specialisations (MG, 2015b), based on the inputs of taskforces, and used as the basis for the first calls for proposals in POIR, launched in April 2015.

In the last quarter of 2015, an additional smart specialisation, related to marine technologies, was added to the list in response to an initiative of industrial companies.

An important feature of the Polish smart specialisation processes is that it is embedded in the broader R&I strategic framework. Poland did not create a separate Smart Specialisation Strategy, as such a document would likely remain disjointed from other policies. Instead, it identified KIS as priority areas, linking them to existing R&I policies and support measures and thus ensuring its impact on the innovation system. All support measures targeting business enterprises take into account the identified specialisations, as KIS is an integral part of the strategic document PRP. R&I funding based on POIR is expected to be allocated mostly to areas defined by KIS, and the calls for proposals launched in 2015 were indeed using KIS to shape project eligibility criteria. Accordingly, future investments in research infrastructures, including those identified in the national roadmap PMDIB, will also need to ensure consistency with KIS, and support for innovation cluster, offered by PARP, will target initiatives consistent with KIS. The broad consultation processes accompanying the development of KIS attracted many stakeholders and contributed to public debates concerning the merits of concentration of R&D efforts.

Moreover, in parallel to the KIS planning processes, MG contracted the World Bank to carry out an extensive evaluation of Polish R&I specialisations, including through interviews with business enterprises. The outcomes of this project are likely to inspire further work of the KIS taskforces and support the smart specialisation monitoring efforts. The successor of the Ministry of Economy, the Ministry of Development (MR) also plans to establish the Economic Observatory, systematically monitoring the specialisation areas (RM, 2015a: 28-29).

The first KIS-related efforts in 2015 encountered several challenges, including limited awareness of business enterprises and consultants, as the shift towards targeted public interventions in R&I system is novel in Poland. Some of the specialisation area has been described in a very extensive manner, incorporating all related technologies and research areas, and thus diluting the potential benefits of focused interventions. Despite precise eligibility criteria for project selection in POIR, in the first call for proposals in 2015, some projects were awarded funding by NCBiR even though their consistency with KIS was disputable.

Another limitation of the Polish smart specialisation approach is the understanding of the essence of smart specialisation strategies. It refers rather to the traditional notion of economic specialisation than to the concept of smart specialisation. They only assume prioritisation of intervention areas by selecting R&D and technology areas of top economic importance. However, they are missing the "smart" dimension, as the proposed interventions would not be differentiated, i.e. every prioritized specialisation would benefit from the same support instruments, even though the actual requirements could be different due to varying technology maturity stages, international competitive situations or readiness of Polish business enterprises to deliver specific solutions.

In addition to the above-described KIS, NCBiR was carrying out a parallel effort, compliant with the recommendations of entrepreneurship discovery process, to prepare for the future distribution of some parts of applied R&D budget. The Centre established so-called "sectoral programmes", which are based on feasibility studies developed by business associations representing industry sectors, outlining specific needs for targeted public interventions in R&D and committing to co-funding of the programme in the public-private partnership model. Sectoral programmes are expected to be adequately adjusted to specific funding requirements of the most R&D-intensive industries, with differentiated intervention forms across sectors, proposed by the prospective beneficiaries from a given sector. The programmes' effectiveness might be warranted by the required financial contribution of representative associations of companies in each sector concerned.

First sectoral programmes have already started issuing calls for proposals (INNOLOT for aviation industry, INNOMED for innovative medicine), and NCBiR established an ongoing call for submissions allowing interested business associations to submit their feasibility studies. The approach demonstrated by NCBiR's sectoral programmes is strongly concerned with stimulating private co-funding, as financial contributions by business enterprises include parts of a programme's budget, distributed to beneficiaries, as well as subsequent co-financing required from each of the beneficiaries, which jointly increase the overall share of corporate expenditures on R&D.

On the regional level, each of 16 regions of Poland defined its own regional smart specialisations, which had been identified through parallel, consultative processes and linked to the Regional Operational Programmes (RPOs), distributing the EU Structural Funds. Regional support for R&I, including investments in research infrastructures, need to be consistent with the identified specialisations. Some of the regional smart specialisations are rather general, targeting broadly defined technologies or market segments (to avoid possible technology lock-ins, as the planning horizon reached the year of 2020).

The Ministry of Infrastructure and Development contracted the World Bank to evaluate the regional smart specialization strategies and recommend possible improvements (Piatkowski et al., 2014), and while the evaluation report criticised the approaches of many regions, the World Bank delivered subsequent contracted services supporting the improvements of regional documents. Regional specialisations are directly linked to RPOs and focus on stimulating private co-funding for projects, while benefiting from the monitoring and evaluation frameworks of RPOs. Regional authorities are also preparing Regional Research Agendas (pl. *Regionalne Agendy Naukowo-Badawcze*), developed with stakeholders and based on the identified regional smart specialisations. These agendas will be used by NCBiR in a dedicated support measure, using POIR funding.

Ministry of Infrastructure and Development (MIR) commissioned in 2014 an analytical report outlining practical options for monitoring and evaluation of smart specialisations on the national and regional level (Pander et al., 2014). The Ministry of Economic Development and PARP will establish the Economic Observatory (*"Obserwatorium Gospodarcze"*), monitoring S3 implementation on the national level, including regular reporting on the implementation of smart specialisations. In addition, an ongoing project by the World Bank evaluates the adequacy of selected specialisations and is expected to propose further improvements, considered to be a "localised", Polish entrepreneurial discovery process. As for regional specialisations, larger regions establish dedicated RIS3 observatories, and all regions have monitoring committees involving stakeholders. The Ministry of Economic Development jointly with regions develops a set of quantitative indicators, which will be used to collect comparable regional data in order to evaluate and monitor the S3 implementation. The central and regional governments collaborate with the Main Statistical Office, the Polish Patent Office and market research specialists to collect the S3-related data, which are expected to be presented through an online portal in an easily comparable manner.

2.5 Main policy changes in the last five years

Main changes in 2011
Legislative reform of the higher education sector
Adoption of National Research Programme (KPB), defining strategic R&D directions
Establishment of the Polish Roadmap for Research Infrastructures (PMDIB)
Main changes in 2012
Implementation of the science and higher education reforms from 2010-2011
Main Changes in 2013
Adoption of high-level policy document – the Strategy for the Innovation and Efficiency of the Economy (SIEG)
First nation-wide institutional assessment of scientific institutions based on new rules
Adoption of draft Operational Programmes 2014-2020 by the government
Multiple new R&D programmes launched by NCBiR, targeting identified funding gaps
Main changes in 2014
Adoption of Enterprise Development Programme (PRP) and National Smart Specialisations (KIS)
Definition of smart specialisations by 16 regions
Relaxing public procurement regulations for R&D at PHEIs and PROs
Legal amendments facilitating the assignment of IPRs to inventing scientists
Amendment of government support programme for FDIs to attract R&D-based investments
Main changes in 2015
Adoption of the Operational Programme Smart Growth (POIR) and 16 regional operational programmes
Launch of first calls for proposals targeting areas identified by national and regional smart specialisations

3. Public and private funding of R&I and expenditure

3.1 Introduction

Table 2 presents R&D funding trends from the recent years and compares the Polish performance with the most recent available EU average. Polish GBAORD and GERD have been constantly growing in nominal terms, but they still remain below the average European levels and the growth occurs at a relatively slow pace. The minor decrease in the GERD to GDP ratio in 2013 can be attributed to the significant expansion of economic activity and GDP growth between 2012 and 2013, but both GERD and BERD experienced year-to-year increases, albeit outpaced by the parallel GDP tendencies. Poland's GOVERD is the EU's 7th largest in absolute terms and has been more than doubled since the country had joined the EU in 2004.

Table 2 Basic indicators for R&D investments.

Indicator	2011	2012	2013	2014	2015	EU average (2014)
GERD (as % of GDP)	0.75%	0.88%	0.87%	0.94%	NA	2.03%
GERD (€ per capita)	€74.5	€90.1	€90.3	€101.6	NA	€560.1
GBAORD (€m)	€1,175m	€1,370m	€1,438m	€1,768m	NA	€93,629.5m
GBAORD (as % of GDP)	0.31%	0.35%	0.36%	0.43%	NA	0.67%
R&D funded by BES (% of GDP)	0.21%	0.28%	0.33%	0.37%	NA	1.12% (2013)
R&D funded by GOV (% of GDP)	0.42%	0.45%	0.41%	0.43%	NA	0.66% (2013)
R&D funded by HES (% of GDP)	0.02%	0.02%	0.02%	0.02%	NA	0.02% (2013)
R&D funded by PNP (% of GDP)	0%	0%	0%	0%	NA	0.03% (2013)
R&D funded from abroad (% of GDP)	0.1%	0.12%	0.11%	0.13%	NA	0.20% (2013)
R&D performed by HES (% of GDP)	0.26%	0.30%	0.25%	0.27%	NA	0.47%
R&D performed by government sector (% of GDP)	0.26%	0.25%	0.23%	0.23%	NA	0.25%
R&D performed by business sector (% of GDP)	0.22%	0.33%	0.38%	0.44%	NA	1.3%

Source: Eurostat, 2016.

The Polish R&I system is dominated by public funding, but a significant increase in the business sector spending on R&D can be observed, with BERD accounting for 0.44% of GDP in 2014, compared with only 0.23% in 2011. Since 2015, the availability of the EU Structural Funds for R&D, targeting business enterprises (POIR) is likely to induce further private investments.

The quantitative data on GERD and BERD are not directly comparable with other countries due to the systematic underreporting of R&D expenditures in Poland, resulting from imperfect data collection procedures. World Bank expressed this presumption in their evaluation of the Polish system of innovations (Kapil et al., 2012: 9). According to a study of innovative companies from the environmental technology sector, prepared for the Ministry of Environment, only 5% of surveyed companies declared that they submit the obligatory annual R&D expenditure forms, even though most of them actively pursued costly R&D initiatives, mostly funded from own sources (Klincewicz et al., 2013: 53). R&D expenditures are not directly presented in financial statements of companies or disclosed by stock exchange-listed enterprises. GUS collects data on BERD based on annual questionnaires, which are compulsory but rarely provided by enterprises, and individual results are protected by the principle of statistical secrecy. Most enterprises are not aware of the informational obligation, and no penalties exist for failure to submit the data. Moreover, the complexity of BERD questionnaires discourages submissions, and the corporate management can always justify such decisions by their lack of knowledge, or uncertainty whether to classify certain expenditures as linked to R&D. NCBiR started asking their beneficiaries to share copies of the annual R&D questionnaires as part of project reporting and this requirement resulted in a sudden increase in BERD reporting, with many companies compiling the data for the first time.

Corresponding problems concern the GERD component reported by PHEIs, where substantial percentages of working time of lecturers is allocated for research, and this can be evidenced by results of the institutional assessment from 2013, including measurable research outcomes. Nevertheless, no standardized methodologies facilitate the division of employment costs between teaching and R&D efforts, resulting in many universities under-reporting the HERD components, only listing their direct financial contributions to publicly co-funded projects. In particular, the actual expenditures on R&D incurred by medical and technical universities as well as researchers in the humanities are likely to go unreported and be higher than the officially stated values.

Potential improvements in R&D data collection procedures might contribute to disproportional increases in GERD statistics. In particular, since significant shares of R&D expenditures by private sector are not reported, raising the BERD statistics might also be feasible through non-financial measures, including awareness campaigns and modification of informational obligations of business enterprises.

When public expenditures on R&D and education are combined and compared with GDP, Poland significantly improves its ranking position within the EU-28 (EC DGRI, 2014: 46). It should be taken into consideration that Polish government maintains two separate budgets for science and higher education, with salaries and maintenance costs of PHEIs not allocated through the science budget (contrary to practices of many other EU countries). This practically means that salaries of researchers working at PHEIs, who combine teaching and research responsibilities, are not classified as R&D expenditures, and a significant share of research efforts by academics remains unaccounted for in the system of R&D financing.

The European Commission contributed €441.349m to Polish beneficiaries from the 7th Framework Programme[10], and the Polish R&I allocations from the EU Structural Funds 2007-2012 amounted to €4,948.3m[11].

3.2 Smart fiscal consolidation

3.2.1 Economic growth, fiscal context[12] and public R&D

In terms of economic growth, Poland weathered the economic crisis rather well with an initial modest slowdown in 2009 to 2.6%, then a strong increase in 2010-2011 to 3.7% and 5%, followed by moderate but still solid growth in 2012-2013: 1.3-1.6% which accelerated again in 2014 (3.3.%) 2015 (3.5%) driven by private consumption (solid real wage, employment growth) and investment (credit recovery, as well as declining production and financing costs). It is expected to remain robust throughout 2016-2017 (3.5% p.a. each year) driven by the same factors.

Although declining, the general government deficit has been above 3% since 2008 and is expected to reach 3% of GDP in 2015 as a result of improving government revenues in line with robust economic activity as well as expenditure restraints related to changes to pension system, increases in indirect taxes and social contributions, public wage and tax thresholds freeze, limited growth in public investment. It is expected to stay broadly at the same level in 2016 (2.8%) and to accelerate in 2017 (to 3.4%) due to the new universal child benefit expenditures.

By 2013, the general government gross debt increased to 55.9% of GDP due to high government deficits and slower economic growth. It fell back to 50.4% of GDP in 2014, following a one-off transfer of private pension funds' assets and on a no-policy change assumption is set to grow again, reaching 53.5% by 2017 (see Figure 2).

[10] Source: RIO elaboration of DG RTD CORDA database.
[11] Source: RIO elaboration of DG REGIO data.
[12] Sources: DG ECFIN, National Reform Program 2015, RIO.

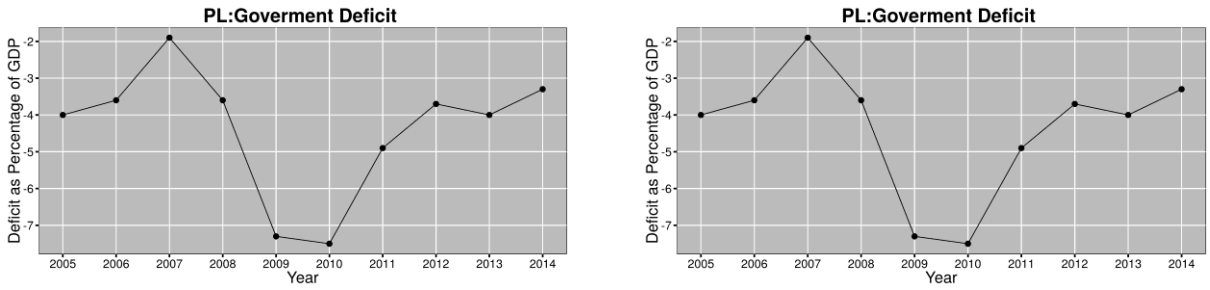

Figure 2 Government deficit and public debt.
Data source: Eurostat, 2016.

Total GERD in Poland was €3,436m in 2013. There are three main sources of R&D funding: the business sector (€1,283m), the public sector (€1,623m), and foreign funding (€451m[13]). Direct funding from the government goes to R&D in the business enterprises (€149m), the government (€743m) and the higher education sector (€730m).

Table 3 Key Polish public R&D indicators.

	2007	2009	2013
GBAORD, % of government expenditures	0.73	0.74	0.86
GERD, % of GDP	0.56	0.67	0.87
out of which GERD to public, % of GDP	0.39	0.48	0.48
Funding from GOV to, % of GDP			
Business	0.02	0.02	0.04
Public (GOV+HES)	0.31	0.38	0.37
Total	0.33	0.40	0.41
EU funding for R&D, % of GDP	0.03	0.02	0.09

[13] The part of the foreign funding of GERD, coming from the EU, was €353m in 2013.

3.2.2 Direct funding of R&D activities[14]

Figure 3, below shows the historical evolution of GERD financing in current prices in Poland.

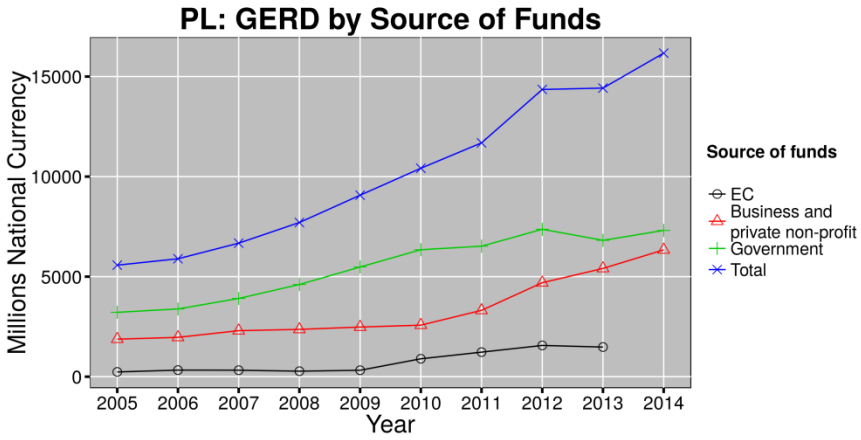

Figure 3 Development of government funding of the total GERD.
Data source: Eurostat, 2016.

The total Polish GERD increased monotonically in the period 2005-2012, and stagnated in 2013 to increase again in 2014. Public funded GERD declines in 2013 to increase slightly in 2014 and the government remains the major funder of the GERD. Nevertheless, after 2010 the share of the government in the funding of GERD considerably shrank due to the increasing funding from the private sector and the European Commission, which are responsible for the significant increases of the overall GERD from 20

3.2.2.1 Direct public funding from the government

Direct public funding is usually the main source of the total governmental support to R&D. Figure 4, below shows the time evolution of the total R&D appropriations (GBAORD) and the GERD directly funded by the government.

The total (civil) appropriations had an increasing trend in the years 2005-2014. Moreover, the 2015 budget foresaw a 10% increase in the budget for science and the government announced further increases in 2016 (by 6% compared to 2015). It should be however noted that the planned state budget for 2016 is expected to introduce important cuts in government budget for R&D, even though the overall science budget will be increased due to the use of EU Structural Funds compared with previous years. This means that part of the national R&D project funding will be no longer financed from the state budget but replaced with the EU Structural Funds, integrated into the science budget.

In 2015, the European Commission terminated the excessive deficit procedure for Poland, and the country will have more flexibility in increasing its government expenditures.

[14] The sources of R&D funding according to the "Frascati Manual" are: Government sector (GOV), Higher education sector (HES), Private non-profit sector (PNP) and Abroad (including EC). In this analysis, the public sector as the source of funds is indicated by the GOV part of the total intramural R&D expenditure (GERD), whereas the public sector as a sector of performance is the aggregation of GOV and HES.

The GERD funded by the government is always higher than the appropriations. There is no clear explanation for this phenomenon, probably due to part of structural funds which are accounted in the GERD but not presented as parts of GBAORD.

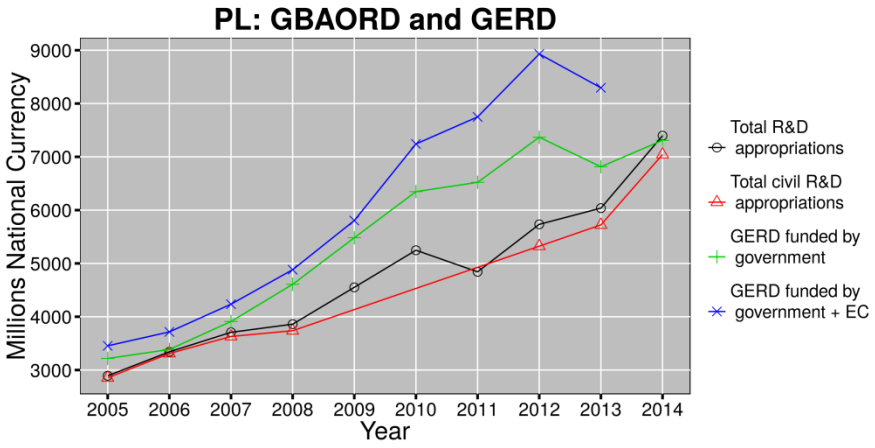

Figure 4 R&D appropriations and government funded GERD in millions of national currency.

Data source: Eurostat, 2016

3.2.2.2 Direct public funding from abroad

Similarly to a number of EU Member States, also in Poland the European Commission is the main external public source of R&D funding. As Table 4 shows, the business sector and International Organisations play a less important role.

Table 4 Public funding from abroad to Polish R&D (in millions of national currency).

Source from abroad	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
Total	320.2	414.6	448.3	417.6	498.6	1231	1565	1915.9	1892.1	2160.7
BES				96	113.7	131.3	140.2	172.7	283.2	
EC	237.2	329.7	324.1	274.4	322	894.6	1227.1	1562.1	1481.1	
GOV								4.7	11	
HES								8.7	7.9	
International Organizations				30.6	48.8	100.4	111.9	117.9	78.1	
Total as % GERD	5.74	7.04	6.72	5.42	5.5	11.82	13.39	13.35	13.12	13.36
EC as % GOVERD	7.37	9.74	8.29	5.96	5.87	14.09	18.82	21.2	21.73	NA

Source: Eurostat, 2016.

Both Figure 4 and Table 4 show that the share of EC funding gradually increases. In 2010, it represented 14% of the direct public funding expressed as GERD funded by government and in 2013 it went up to 21,7%. This increase can be partially attributed to the life cycle of the allocation of the structural funds (less at the beginning of the programming period and more towards the end).

Based on data from DG REGIO, Structural Funds for the period 2007-2013 for Poland amounted to €67.2b, of which €4.9b were dedicated to 'Core' R&D activities (i.e. 7.4%). Compared to other EU Member States, Poland has a low share of structural funds allocated to R&D, below the corresponding share at EU-28 level, i.e. 9.4% (Annex 5)[15].

Compared to €4.9b structural funds for R&D, the FP funding role in Poland's public funding is negligent– €266m for FP6 (1.7% of the total EU contribution) and €442m for FP7 (1.1%). What is more, Poland (similar to other EU-13) has not managed to preserve its share of EU contribution in the FP7 programme.

Yet, Poland plans to significantly increase its participation in Horizon 2020 through different policy measures e.g. Pact for Horizon 2020 (a voluntary agreement of MNiSW with interested PHEIs and PROs, ensuring additional organizational support for research teams applying for funding and implementing Horizon 2020 projects, and offering co-funding to successful applicants) and through support measures stimulating synergies with Horizon 2020 and facilitating applications to the EC programmes.

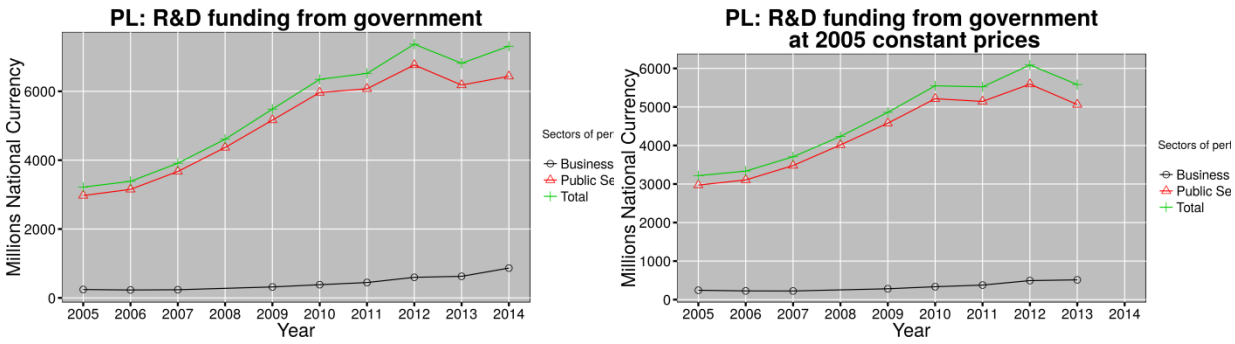

Figure 5 Government intramural expenditure by sectors of performance.
Data source: Eurostat, 2016.

Figure 5 shows how the government expenditure for R&D is distributed between the public and the private sectors. Unsurprisingly, the public sector is the main recipient of government funded GERD and increases significantly from 2005. In 2013 a drop in the total R&D expenditure funded by government, affects only the public sector. Direct contribution from the government to the business R&D is very limited, although somehow increasing from 2010.

[15] The substantial discrepancies between statistics on R&D expenditures from the EU Structural Funds based on Annual Allocation Reports from DG REGIO and R&D expenditures reported by R&D performers in Poland and included in the GERD demonstrate the scale of R&D underreporting by business enterprises in Poland.

3.2.3 Indirect funding – tax incentives and foregone tax revenues

Poland has introduced two tax incentives: technology tax relief (2006) and tax deduction for firms with the status of R&D Centres. Since 2012, important changes to tax incentives system were under discussion. The 2014 and 2015 National Reform Program (NRP) do not include any government plans for the introduction of new R&D tax reliefs, recommended in Country Specific Recommendations for 2013 and 2014. In September 2015, the Parliament adopted the Act on Amendments of Some Acts with respect to the Support for Innovativeness, based on a proposal submitted by the former President. The Act was signed in October 2015, and it will enter into force in 2016.

The initial version of the Act included substantial tax exemptions for R&D performers, but they were removed in the subsequent parliamentary work. It has to be noted that the 2013 NRP programme foresaw the introduction of new tax incentives after Poland exits the Excessive Deficit Procedure.

Table 5 Technology tax relief – amounts, numbers of beneficiaries, and foregone tax revenue due to the tax exemptions.

Technology Tax Relief	**2010**	**2011**	**2012**	**2013**	**2014**
Number of beneficiaries	33	97	94	75	80
Tax relief in total	€7.833m	€65.770m	€104.990m	€73.959m	€67.821m
Average relief	€0.237m	€0.678m	€1.117m	€0.986m	€0.848m
Foregone Tax Revenue	€1.488m	€12.496m	NA	NA	NA

Source: Ministry of Finance Information on income tax for corporate entities, 2010-2014.

In 2010, only 33 companies used tax exemptions for acquisition of new technologies, with an average exemption of €237k, and after amending the relevant legislation, in 2011 the number of beneficiaries went up to 97 and average exemption increased to €678k. As from 2012, the number of beneficiaries started to decline but the average exemption value nearly doubled to €1.117m. The high average relief suggests that this tax incentive is used mostly by large companies. Forty two companies had the R&D Centre status in 2015[16]. The tax exemption will no longer be available in 2016, as stipulated by the Act on the Amendments of Some Acts with respect to the Support for Innovativeness. There is no recent information on the foregone tax revenue for this tax measure.

OECD[17] estimates that indirect support to R&D in Poland in 2011 corresponded to 0.0004 %GDP, which was very low compared to the direct funding, see Figure 6.

[16] http://bip.mg.gov.pl/O+ministerstwie/Jednostki+organizacyjne+nadzorowane+lub+podlegle/Centra+badawczo+rozwojowe

[17] http://www.oecd.org/sti/rd-tax-stats.htm

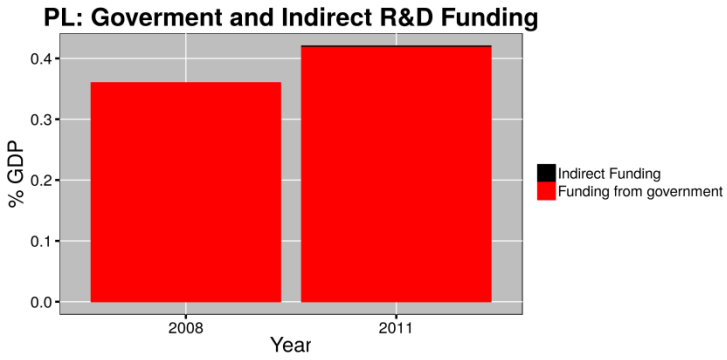

Figure 6 Direct and Indirect funding of R&D.
Source: OECD.

3.2.4 Fiscal consolidation and R&D

As we have seen in Figure 4, the only time GBAORD decreased in the post-crisis period was in 2011. When presented as a share of GDP, the fall is stronger, due to the stronger GDP growth in 2011. On the contrary, government GERD, which in 2011 has fallen only as % of GDP drops in 2013 both in nominal and relative terms.

Figure 7, below shows the scatterplot of the structural balance and a relevant measure of the R&D (GBAORD as % GDP, first panel and GERD as % GDP, second panel)[18]:

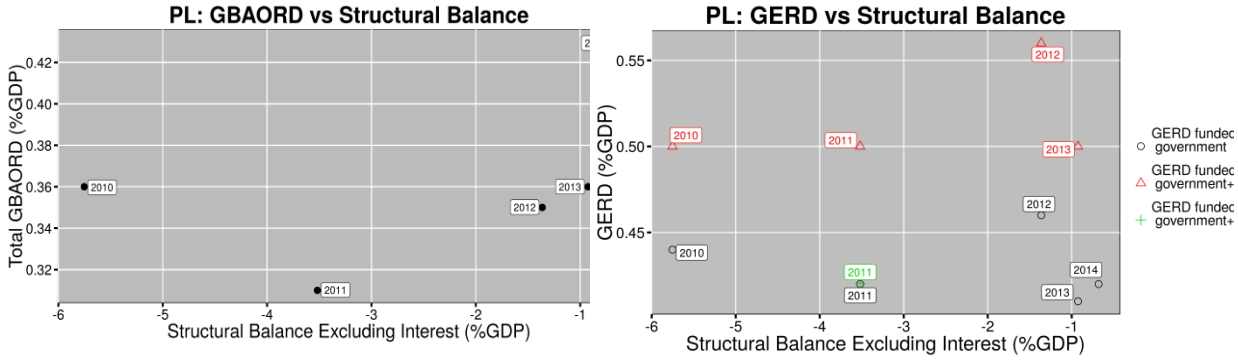

Figure 7 Fiscal consolidation and R&D
Data sources: AMECO, Eurostat.

According to Figure 7, the fiscal consolidation process had a small negative impact on the budget appropriations for R&D between 2010 and 2011 which was soon reversed and completely overcome by 2014. In other words, while the structural balance keeps improving GBOARD has increased further to its 2010 levels.

[18] Structural balance data comes from the AMECO database the other indicators were taken from Eurostat.

However, with a deficit of still 3-4% in 2013-2014 (Figure 2) and a structural balance of around -1% at the same period we cannot state that fiscal consolidation has been accomplished in Poland.

The evolution of the R&D expenditure funded directly by the government vis a vis the structural balance follows a similar pattern up to 2012. Further improvement of the structural balance in 2013 led to a small decrease of the government funded R&D expenditure both in nominal and relative terms, which did not continue the year after.

A second key observation is that the EU funding was important for the public funding of the Polish R&I system during the fiscal consolidation period, whereas adding indirect funding to direct public support does not have any material effect (at least in 2011 for which data is available).

Therefore above evidence shows that the Polish government managed to exit the excessive deficit procedure while increasing the R&D appropriations. Yet, part of the increase was gained through using the EU Structural Funds and its role increases year by year, which in the longer term (after 2020) may pose a problem with sustaining the budgetary efforts at the same level.

3.3 Funding flows

3.3.1 Research funders

Funding for R&D is primarily allocated by two government agencies: NCN (financing fundamental research, performed mainly by academics) and NCBiR (funding applied R&D, with beneficiaries representing both the business and the science sector). Some competitive project funding is directly distributed by MNiSW (including dedicated programmes for humanities, and support for commercialisation of research results at PHEIs and PROs), and the Ministry allocates also institutional funding to all science sector organisations based on the outcomes of institutional evaluations. Most project funding competitions are not restricted to PHEIs and PROs, and business enterprises can benefit from these funds as long as they submit ambitious project proposals. This arrangement facilitated access to science funding by private sector organisations and was one of major achievements of the 2010-2011 reform of the science sector, but is still criticized by some representatives of PHEIs and PROs. Funding for research infrastructures at PHEIs and PROs is distributed by the Information Processing Centre (OPI, *Ośrodek Przetwarzania Informacji*), a research institute supervised by the Ministry of Science and Higher Education. The legal framework for the above-mentioned funding activities is defined by the Act on Principles of Financing Science with related executive acts (ordinances), and each type of competitive funding (R&D programme) has its own written modalities.

Funding for business enterprises is distributed based on separate regulations concerning public aid. An agency of the Ministry of Economic Development, PARP, offers broader R&I financing to business enterprises, including support for implementation of innovations, IPR protection and research infrastructures, as well as co-funding for preparation of applications to international programmes such as H2020. MR also co-ordinates some measures, which target companies, in particular it can offer special tax exemptions and co-funding for major investors, including both foreign and domestic companies. ARP and KFK can invest in selected private sector companies, acting as sovereign investment funds, and the state-owned bank BGK offers financial instruments, stimulating private sector's innovativeness, including credits for implementation of new technologies.

Additional funding for R&I might come from private sector entities, including business angels, investment and VC funds, as well as the Warsaw stock exchange with its *NewConnect* platform, dedicated for smaller, innovative companies.

Another important research funder is FNP, the Foundation for Polish Science, which is a non-government foundation, offering highly selective programmes focused on research excellence. FNP has own financial resources, derived from a large government donation from the 1990s, but most of its programmes rely on the distribution of the EU Structural Funds, complementing the activities of NCBiR and PARP.

3.3.2 Funding sources and funding flows

Table 6 outlines the shifting importance of various R&D funding sources, represented as shares of GERD. Since 2011, when a wide-ranging institutional reform of the R&D system was introduced, the relative importance of private funding for R&D increased, accompanied by parallel increases in the R&D funding provided by foreign enterprises, and in 2014, the R&D performed by business enterprises accounted for 46.58% of GERD. As explained in chapter 3.1, a part of BERD escapes the official R&D accounting regime, so the actual importance of business enterprises is likely to be higher than the above-listed figure, which consists in a substantial part of private sector contributions in publicly co-funded projects (i.e. cases when companies are contractually obliged by NCBiR to report their R&D expenditures). Among foreign sources, the European Commission is the major source of R&D funding, but with only 10.27% of GERD in 2013 (no data available for 2014), its contribution is more limited compared with the Polish government (47.24% of GERD in 2013, 45.21% in 2014). Private not-for profit organisations and other international sources play an insignificant role in the funding system.

Table 6 Shares of GERD by funding sectors.

GERD funders	**2011**	**2012**	**2013**	**2014**
Government	55.80%	51.33%	47.24%	45.21%
Business enterprises	28.12%	32.30%	37.33%	39.00%
Higher education	2.44%	2.60%	2.13%	2.23%
Private not-for profit organisations	0.25%	0.41%	0.18%	0.20%
Foreign sources	13.39%	13.35%	13.12%	13.36%
including EC (EU Framework Programmes and EU Structural Funds)	10.50%	10.88%	10.27%	NA
including foreign business enterprises	1.20%	1.20%	1.96%	NA
including other international sources	1.69%	1.26%	0.89%	NA

Source: own calculations based on data by the Central Statistical Office and Eurostat.

Public R&D funding in Poland is primarily covered by the so-called science budget, which formally constitutes the 28th section of the national budget, is subject to standard planning and reporting procedures. The science budget is planned by the Ministry of Science and Higher Education based on multi-annual plans, programs, relevant legislations and agreements with other ministries, and it includes among others funds distributed through government R&D funding agencies NCN and NCBiR, both to public and private sector. Importantly, the science budget does not include many relevant expenditures, such as:

- funding for PHEIs and PROs, covering the salaries of researchers and maintenance of building and/or infrastructure (even though some of these expenditures can be considered relevant for R&D activities),
- funding for R&I distributed by regional agencies (which used to be limited in 2007-2013, but became sizeable in the 2014-2020 perspective, as the regions are now empowered and play important roles in distributing the EU Structural Funds for R&I, taking into account regional smart specialisations),
- funding for R&I distributed by agencies of the Ministry of Economic Development.

Due to inconsistencies in financial planning and reporting approaches, the above-listed examples of spending are not covered by the 28th section of the state budget and even though at least some of these expenditures are consistent with definitions of R&D expenditures in "Frascati Manual", they are not reported in official statistics as linked to Research & Development efforts. This limitation needs to be taken into consideration when analysing R&I funding sources and flows in Poland.

The Polish state budget remains a significantly more important source of R&D funding than the EU Structural Funds or the EU Framework Programmes. Total financial contribution of the European Commission to beneficiaries of the 7th Framework Programme from Poland amounted to €441.349m, and was distributed among 1,728 projects with 2,224 Polish participants[19]. In Horizon 2020, 418 Polish participants and 49 coordinators implement 281 projects, receiving only about 1.0% of the overall program funding allocated to the EU participants[20].

More important were the EU Structural Funds, but their importance for R&D in Poland seems to be over-rated in popular interpretations, as the total funding for R&D from this source was actually much smaller than the R&D expenditures of foreign companies operating in Poland, or budgets of government-funded R&D programmes. In 2014, government funds accounted for 70.94% of the science budget, and the EU Structural Funds only corresponded to 29.06% of the overall budget.

The total R&I allocation of the EU Structural Funds for Poland for 2007-2012 was €4,948.3m, being the largest budget among all EU member states and 16.4% of the EU-wide R&I allocation from the Structural Funds[21]. By the end of 2013, Poland's Annual Implementation Report indicated the allocation of €11,404.9m to projects related to research and technological development, innovation and entrepreneurship (with 92.8% absorption rate for 2007-2013), based on multiple operational programmes on the national and regional levels. (JRC-IPTS, 2015: 10).

[19] Source: RIO elaboration of DG RTD CORDA database.
[20] Source: RIO elaboration of DG RTD CORDA database.
[21] Source: RIO elaboration of DG REGIO data.

There is a major discrepancy between these data and the officially registered R&D expenditures, based on the EU Structural Funds according to the analyses of the Polish Central Statistical Office, as the majority of EU funds in 2007-2013 were spent on innovation-related activities that were not directly classified as R&D, such as: establishment of research infrastructures, support for knowledge transfer, implementation of new manufacturing technologies, patenting, R&I-related capacity building in the science and business sectors or funding for technology start-up companies. While at least part of these expenditures could be interpreted as directly contributing towards GERD, most of them were not reported by the performing organisations as R&D and thus, not accounted for in national R&D statistics. This has led to a situation in which the EC-registered funds for R&I in Poland are substantially higher than R&D funding based on the EU Structural Funds, which are listed in national reports. It needs to be emphasized that the parts of EU funding not accounted for in national R&D statistics were not misappropriated, nor were they allocated for purposes other than R&I – but the discrepancy in question resulted from flawed R&D reporting procedures.

Absorption rates of the EU Structural Funds were relatively high in the financial perspective of 2007-2013, and the implementation agencies were able to quickly react to challenges by amending work programmes or launching new support measures to supplant unsuccessful instruments.

In the 2014-2020 perspective, operational programmes include proportionally higher sums directly allocated to R&D projects, and thus the direct influence of the EU Structural Funds on Poland's GERD is likely to increase. There is however a risk that the wide availability of EU funding for R&D might crowd out the present government funding in the same area, as support measures offered in POIR were designed taking into account the best practices of the funding agencies and instruments they were offering in the past.

The private sector funded 36% of GERD in 2014, and its importance in R&I funding was increasing, but as explained in chapter 3.1, many R&D expenditures of business enterprises remain unaccounted for by national statistics.

Foreign-owned companies offer substantial R&D contributions and accounted for 45.76% of BERD in 2013, amounting to €687.86m (GUS, 2015a). R&D expenditures related to FDIs rarely result from relocations of existing R&D activities by foreign companies, but rather present greenfield-type investments in new technology development projects. The Polish government started actively attracting R&D FDIs in recent years. The government agency dealing with foreign investments, PAIZ, treats R&D investments as a priority, with focused efforts of PAIZ specialists interacting with potential investors, and the Ministry of Economic Development offers subsidies to prioritized FDI projects, based on the "Programme for the support of investments of considerable importance for Polish economy for years 2011-2020". The registered increases in R&D funding from foreign investors in 2012 and 2013 proved to be significant. Foreign companies started also introducing more sophisticated financial schemes, e.g. with Google financing in 2014 the Digital Economy Lab (DELab) at University of Warsaw, intended to spur technology start-ups and intensify the development of open innovations in Poland, and opening Google Campus in Warsaw. NCBiR cooperates with foreign and local VCs, co-funding the establishment of dedicated funds to support the commercialization of R&D-based companies.

3.4 Public funding for public R&I

3.4.1 Project vs. institutional allocation of public funding

The increased importance of competitive funding resulted from an overhaul of the R&D system in 2010-2011. The present system relies heavily on the distribution of competitive funding (both project funding and competitively-distributed institutional funding), and links the institutional funding to results of regular institutional assessments, verifying the research excellence. In 2015, modalities for institutional funding distribution were refined, but the amendments were focused on correcting certain shortcomings and facilitating data collection (comp. chapter 2.2), without changes to the underlying principles. In 2014-2015, the planning for the new EU Structural Funds influenced some R&D funding streams by linking them to national or regional smart specialisations or requiring scientific organisations to form consortia with business partners in order to apply for funding in POIR.

The balance between project and institutional funding evolved in recent years, as demonstrated by Table 7. Before the 2010-2011 reform, institutional funding was dominant in the science budget, while in 2014, 65.14% of the government R&D budget were distributed through competitive calls for proposals, and 29.17% - allocated based on the outcomes of institutional assessments. According to the planned budget for 2015, 59.72% corresponds to project funding and 31.52% to institutional funding. Two main R&D funding agencies, NCN and NCBiR, distribute all of their R&D funds as project funding, and they jointly distribute over half of annual science budgets through competitive calls for proposals (56.68% in 2013, 57.46% in 2014, 52.07% planned for 2015).

Table 7 Project versus institutional funding as shares of the overall science budget, 2009-2015.

Year	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015 (plan)**
Share of institutional funding	45.98%	33.54%	31.81%	32.94%	30.33%	29.17%	31.52%
Share of project funding	44.63%	48.36%	57.55%	63.61%	64.46%	65.14%	59.72%
Share of project funding distributed by NCN and NCBiR	0%	0%	19.97%	54.25%	56.68%	57.46%	52.07%

Source: own calculations based on MNiSW annual budgetary plans and budget execution reports.

3.4.2 Institutional funding

Institutional funding is allocated based on the outcomes of nation-wide institutional assessments, using criteria defined by MNiSW ordinance and implemented by KEJN (the Committee for Evaluation of Scientific Research Institutions). The allocation procedure is clearly linked to research performance. The detailed assessments include: bibliometric measures (with counts of publications taking into account impact factors of specific academic journals, patents, revenues from industry co-operation and external R&D funding, normalized by numbers of R&D employees of an organization), scientific awards of researchers, patents, and financial results of commercialization of research results.

In 2013, evaluation criteria were substantially modified to further promote organizations conducting world-class research, and the evaluation process is supported by a central IT system to eliminate the risks of human error or duplication of records for researchers working at more than one scientific organization.

In 2015, MNiSW worked on modifications of the criteria, based on lessons learned from the 2013 evaluation exercise, and the proposed changes were supposed to eliminate ambiguity or limit the potential for abusing the system (e.g. publications jointly authored by several organisations would be calculated based on fractional counting, weighting their co-authoring institutions so that the same article is not counted multiple times). The evaluation is quantitative and automated, with transparent and standardized rules, without any qualitative component or peer reviews. It does not take into account broader impact of research, and limits the analysis to measurable bibliometric or financial variables (counts of publications, citation-based measures, values of R&D grants and knowledge transfer agreements). The assessment in 2017 will be carried out according to updated methodology prepared after consultations with stakeholders albeit changes were not substantial[22].

Based on the outcomes of the evaluation, organizations fall into specific research categories. The best performing research organisations receive 'A+' or 'A' category, good ones 'B' and the least performing ones - 'C' category. The organisational assessments are carried out at the level of separate faculties (not entire universities, i.e. worse-performing parts of a university cannot benefit from successes of other departments/faculties).and the assigned amount of institutional funding is calculated based on the category and number of full-time researchers, employed by the organization (statutory funding), with dedicated part of funds assigned for young researchers and doctoral students. The institutional funding is expected to be used for purposes related to research and publication of research results. Beneficiary organizations apply each year for the funding, outlining ongoing research projects, which would be supported from the budget, and afterwards report the results accomplished. The institutional assessments are carried out on the level of individual institutes and faculties (not entire universities, i.e. worse-performing parts of a university cannot benefit from successes of other departments).

A formally defined algorithm determines the level of organisational funding based on: (a) the outcomes of the most recent organisational assessment and (b) the level of funding, which was granted based on previous assessment. However, part (b) of the algorithm has been gradually decreasing since 2010 and disappeared altogether in 2015 with the new ordinance on financing statutory activities of scientific units[23] In 2014 the block funding was still at the level of 77% of the amount received in 2013. Therefore in order to alleviate negative consequences which may stem from the first assessment in 2013 in the intermediate period (till 2017) there are maximum threshold for increasing or decreasing the funding for a research institute per number of full-time researchers.

In 2013, PHEIs and PROs went through the first assessment, based on the new pro-effectiveness regulations. 3.8% of all 963 scientific institutions were awarded the highest "A+" rank, and 31.9% were assigned to the "A" class. The results are directly linked to the institutional funding, awarded from the science budget, but the number of institutions distinguished within the "A" category might be considered too high, thus limiting motivations for continuous improvements but satisfying the expectations of the scientific community.

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[22] Comp. Rozporządzenie Ministra Nauki i Szkolnictwa Wyższego z dnia 11 września 2015 r. w sprawie sposobu ustalania wysokości dotacji i rozliczania środków finansowych na utrzymanie potencjału badawczego oraz na badania naukowe lub prace rozwojowe oraz zadania z nimi związane, służące rozwojowi młodych naukowców oraz uczestników studiów doktoranckich, http://www.bip.nauka.gov.pl/g2/oryginal/2015_09/f8174d83f4cb3de1f063b3d87c6e3572.pdf)

[23] http://www.dziennikustaw.gov.pl/du/2014/1941/1

Contrary to some opinions concerning the evaluation, scientific institutions assigned to the lowest, "C" class, are not dissolved or merged with other organisations, but rather motivated to improve their research activities with very limited funding available for them in the year following the evaluation. Moreover, based on formal appeals, in 2014 – over a year after the assessment was finished - 49 scientific institutions were upgraded to higher classes. This lengthy delay demonstrates weaknesses of the procedure, but at the same time suggests that the approach is transparent and open, allowing for corrections of possible mistakes when analysing the data.

A formally defined algorithm determines the level of institutional funding based on: (a) the outcomes of the most recent institutional assessment and (b) the level of funding, which was granted based on previous assessment, but part (b) of the algorithm was gradually decreasing since 2010 and disappeared in 2015. PHEIs also benefit from additional funding for teaching, which is not classified as R&D expenditure (and thus not included in the data summarized in this report), but is vital to ensuring the continuity of operations, distributed as block grants and since it covers parts of university researchers' salaries, can in practice support also some R&D activities.

An additional source of institutional funding is the "KNOW" competition, identifying a small number of research excellence centres in selected disciplines, based on applications reviewed with the involvement of international experts.

3.4.3 Project funding

Project funding for public R&I is offered by NCN, NCBiR, MNiSW and FNP, with support measures targeting distinctive topics, types of research or target audiences. Their detailed list is provided in Annex 4. Annex 5 presents the data about recent evaluations of selected programmes, but the support measures targeting PHEIs and PROs have not been subject of dedicated evaluation exercises in recent years. Chapter 2.2. offers more detailed information about support measures, which were introduced or modified in 2013-2015.

Researchers at PHEIs and PROs primarily benefit from the fundamental research funding offered by NCN, and NCN's programs are differentiated by types of applicants (including: for doctoral students, researchers who were awarded PhD a given number of years before the application date, experienced research teams, the most experienced researchers and projects involving foreign scholars).

Funds distributed by NCN are subject to competitive calls open to all interested institutions and individuals, and the Centre does neither determine eligible research topics nor scientific disciplines. Applicants select the relevant scientific panels, i.e. identify the research domain, which will be represented by reviewers. NCN projects are person-bound, i.e. directly linked to the primary investigator identified in the project application, but also at the same time they need to be implemented by the organisation applying for the funding (more information concerning grant portability is provided in chapter 4.4.3).

In 2014, NCN received altogether 11,432 project applications for €1,186.9m and issued positive funding decisions for 1,804 projects with the overall value of €181.6m (success rate: 15.8%, average funding per project: €100.6k)[24]. In 2015, NCN took active measures to limit the personnel costs in R&D project budgets by defining upper limits of financial rewards for different groups of researchers and restricting the share of budgets, which could be allocated as indirect costs (NCN, 2015b).

[24] Calculations based on: MNiSW (2015a: 142). Detailed success rates for individual funding programmes listed in: NCN (2015a).

The funding modalities encourage the use of grants for the purchases of equipment, materials, external services, publishing, travelling or participation in conferences but limit the potential financial rewards for the research team, which is expected to be funded from regular salaries at their employing institutions.

NCBiR programs focus on applied R&D and many support measures are not available to public R&I institutions but only to business enterprises or to consortia, involving scientific and industrial partners. This situation has resulted from a gradual evolution of NCBiR's focus in recent years, as the Centre's primary beneficiaries are now business enterprises not scientists. In 2011, 51.02% of projects funded by NCBiR were implemented by PHEIs or PROs, benefiting from 43.19% of the allocated funding, but these shares dropped in 2014 respectively to 36% of projects funded and 26.44% of allocated financing for public R&I beneficiaries[25]. The above-described tendency might lead to a funding gap for applied R&D projects carried out by researchers not affiliated to companies, and preferences for funding the development of technologies for which very specific applications are identified and commercialisation plans elaborated already in funding proposals, while disregarding potentially more innovative but less defined applied research endeavours, proposed by scientists. NCBiR manages multiple R&D programmes, including both broad-sweeping competitions (with topics of research defined in a bottom-up mode, based on interests of applicants), as well as initiatives targeted at specific technologies, research areas or groups of applicants. In 2014, NCBiR received 4,862 project applications and signed 700 funding agreements with beneficiaries (NCBiR, 2015b: 4-5), but the streams of applications and funding decisions were converging in time, so the success rate of 14.39%, calculated based on the data available, can only be regarded as a rough estimate.

NCN rejects project proposals, which involve applied research and/or technology development, and criteria and modalities in many of NCBiR's support measures (including measures based on POIR) require the proposals to be submitted by companies or consortia with the leading role of companies. Over time, NCBiR has proportionally decreased its share of funding allocated to individual business enterprises (2011: 50.56% of the allocations, 2014: 23.14%) shifting it towards consortia involving both private and public partners and thus promoting knowledge transfer and open innovations (2011: 5.71% of the allocations, 2014: 48.19%) (NCBiR, 2015b: 25).

For both NCN's and NCBiR's programmes, applications go through a peer-review process with more than one reviewer per application. Some programmes supplement the paper-based applications by applicants' presentations in front of evaluation panels. The reviews are based on detailed criteria related to the quality of the project and relevant experiences of the applicant, and reviewers sign agreements confirming lack of conflicts of interest. Applicants receive detailed information about the outcomes of peer-reviews and can appeal the decisions by addressing specific remarks of reviewers. Quantitative measures assigned by reviewers to all applications in a given call for proposals are used to establish a ranking, with top applicants receiving the funding.

Project applications submitted to NCN have to be prepared in Polish and English (the Council of NCN may indicate scientific disciplines for which these language requirements do not apply and currently, researchers representing humanities and social sciences can opt to prepare applications in Polish only). Peer-review rules are defined by publicly available procedures and compliant with international standards for peer-reviews, and foreign reviewers are involved in the evaluation of proposals. In 2014, 62% of proposals at NCN were evaluated by foreign reviewers (MNiSW, 2015a: 142). In 2013, NCN started publishing on its websites names of members of evaluation panels after the evaluations are completed, in order to increase the transparency of the process.

[25] Calculations based on: NCBiR (2015b: 25).

NCBiR selects reviewers from a database compiled based on individual submissions of scientists interested in becoming the reviewers or using bibliometric tools. Peer-reviews rules are transparent, and compliant with international standards, and in many programmes, applicants are obliged to submit project descriptions in English. Nevertheless, the actual involvement of foreign reviewers is limited, with low financial compensation being a potentially limiting factor. NCBiR's bylaws stipulate that detailed terms of co-operation with foreign reviewers are determined on a case by case basis, thus allowing for deviations from the standard compensation, foreseen for Polish experts. The reliance on the core principles of peer-review is also required for all R&I funding distributed based on the new operational programme for 2014-2020 (POIR).

A small number of R&D projects is funded by FNP (the Foundation for Polish Science), which focuses on highly-selective processes to support research excellence and younger scientists, and its evaluation procedures involve foreign reviewers and presentations of candidates in front of panels of experts. FNP's portfolio of support measures includes a local counterpart of the ERC Starting Grant, targeting the most promising young researchers, planning breakthrough research and establishment of international R&D teams. Supplementing the NCN and NCBiR programmes, MNiSW manages the National Programme for Development of Humanities (funding large R&D projects in humanities and social sciences), IUVENTUS PLUS (funding R&D projects by young researchers) and IDEAS PLUS (for positively evaluated finalists of the ERC competition "IDEAS", who did not receive ERC funding).

3.4.4 Other allocation mechanisms

Specific programmes target science-industry co-operation and commercialization of research at PHEIs and PROs, including: NCBiR's SPIN-TECH (for technology transfer companies, established by PHEIs and PROs), MNiSW's Innovation Brokers (financing technology brokers for PHEIs), and MNiSW's "Top 500 Innovators" (dedicated training programmes at leading US universities for researchers and technology transfer professionals). PARP offers "innovation vouchers", used by business enterprises to order product development services from scientific organisations. There are also dedicated funding schemes for research infrastructure. All of the above described types of funding are based on open competitions, but might not be directly classified as R&D funding. There are also some R&D projects contracted by government to scientific organisations based on public procurement procedures in the areas of defence, health and policy analysis. Some PROs benefit also from contracts with their supervising ministries, which delegate some analytical tasks to the affiliated research institutes. Moreover, PHEIs benefit from substantial funding distributed by MNiSW, calculated based on an algorithm taking into account the numbers of students and employees, and used to cover the costs of educational services, salaries, building and equipment maintenance, thus offering a stable financial basis for the R&I efforts. In a similar manner, many operational costs incurred by PROs and by the Polish Academy of Sciences are covered by MNiSW or other ministries, and not listed as R&I funding in national statistics.

3.5 Public funding for private R&I

3.5.1 Direct funding for private R&I

Annex 4 lists the R&I support measures, including measures targeting business enterprises. All of the support measures involve peer-review, with selection criteria and procedures determined by by-laws and regulations. Annex 5 includes data about recent programme evaluations and lessons learned concerning R&I support measures for business enterprises, implemented in recent years and/or planned for the 2014-2020 financial perspective.

When applying for public R&I funding, companies tend to focus on applied not fundamental research. Out of 1,804 project proposals, selected for funding by the fundamental research agency NCN in 2014, only 14 were submitted by business enterprises, foundations, associations or hospitals (MNiSW, 2015a: 34).

In 2015, the Ministry of Science and Higher Education worked on refining the modalities for granting public aid by NCN in order to stimulate business interests in basic research and co-operation with scientists (comp. description in chapter 2.2).

The majority of R&D funding for companies is distributed by NCBiR. In recent years, the agency has focused on a systematic targeting of gaps, identified throughout the entire innovation cycle, from research to market innovation. Specific programmes were launched to fill in gaps in the process, such as: chasm between the fundamental research and applications-oriented endeavours (TANGO), prototyping of technologies based on applied research results (DEMONSTRATOR+), protecting IPR (PATENT PLUS), financing innovative projects at the start-up and subsequent growth phases, with the help of private capital (BRIdge), and exploring the potential of the foreign markets for advanced technologies (GO_GLOBAL.PL). Importantly, some programmes are particularly suitable for applicants who previously benefited from another, preceding support measure. Similar structure is replicated in the distribution of the EU Structural Funds through POIR, which takes into account the most positively evaluated measures from the NCBiR's portfolio, and offers instruments corresponding to all parts of the innovation cycle. In the course of programme evaluations, some beneficiaries of public funding expressed desire to have just one instrument, which assures funding throughout this multi-staged process, but such an approach might be controversial, reducing competition and eliminating multiple entry points for R&D financing.

Many available support measures take into account societal challenges, including challenges in the areas of health, environment, agriculture and energy, and some programs were specifically launched by NCBiR to target these challenges.

Public R&D funding is intended to leverage private finance and induce proportional increases in BERD. NCBiR monitors the co-funding by private sector, collects and summarizes data on corporate investments resulting from their grant decisions (PwC, 2014). The agency introduced several grant programmes as public-private partnerships, stimulating the financial contributions of business enterprises and thus disproportionally increasing BERD. They combine private and public finance with a part of funds covered from the state budget, another part coming from private sponsors and additional requirements for own contributions by the grant beneficiaries. In this way, the necessary private funding for individual projects is multiplied compared to traditional grant programmes. The principle applies to the following programmes: BRIdge, CuBR, RID, INNOLOT, INNOMED, and will also be used for sectoral programmes in the future. The average co-funding provided by NCBiR to projects implemented by business enterprises was 69.2% of overall project budgets in 2013 (NCBiR, 2015b: 37), and budgets of R&D projects implemented by companies using the NCBiR's support corresponded to 34.6% of BERD (NCBiR, 2015b: 38). The total private co-funding contributed by business enterprises was €197.36m in 2014 (NCBiR, 2015b: 5).

Innovative companies can also benefit from multiple market-based opportunities to finance product development and corporate expansion, including: business angel networks (some benefiting from public co-funding), VCs (17 funds were established with 50% public contribution from KFK), technological credits (available from the state bank BGK), dedicated stock exchange *NewConnect* (targeting earlier-stage innovative companies), as well as public sovereign fund PIR (focused on large, capital-intensive investments). These combinations of private and public financing will also be available in 2014-2020 as the most effective instruments from the previous financial perspective were replicated in POIR.

NCBiR implemented measures reducing administrative burdens of participating business enterprises, in particular SMEs. Contents of project applications and evaluation criteria were streamlined and simplified in 2015 on the occasion of the launch of POIR-based support measures.

Written applications are relatively short, but applicants need to discuss the merits and limitations of their R&D proposals with selection panels, and the funding decisions are linked to research excellence and impact criteria, known from Horizon 2020. The most popular R&D support measure, POIR 1.1.1 (popularly referred to as "*Fast track*", pl. *Szybka ścieżka*), involves NCBiR's commitment to make funding decisions within 60 days from the submission of applications, and experts evaluating proposals include representatives of the financial and business community.

The Polish government increased in 2014-2015 its support for applications to Horizon 2020 and other international R&I programmes by business enterprises. The National Contact Point started working closely with SMEs and large technology companies, not only scientific institutions. PARP offers co-funding for private sector applicants to international R&I programmes. NFOŚiGW supports Polish participation in LIFE programme. Many domestic support measures were designed in ways intentionally stimulating synergies with Horizon 2020 and facilitating future applications to the EC programmes (comp. Klincewicz, 2015b).

In recent years, public funding for innovation in Poland extended beyond the support for R&D. The absorption of externally sourced technologies and knowledge was perceived as an important way of modernising the economy, increasing its innovativeness and improving the total factor productivity. The main stream of RDI funding based on the EU Structural Funds in 2007-2013, POIG, included multiple support measures related to innovation rather than R&D.

The government agency PARP assumed a leading role in promoting the innovativeness of business enterprises, including by: distributing public funds, co-ordinating training activities through the network of certified service providers KSU, and conducting awareness campaigns. These Polish initiatives preceded the more recent European interest in non-R&D-related innovations and can be a source of many good practice examples, but at the same time, some observers were critical of them claiming that large shares of POIG funding were used to fund imports of foreign technologies and know-how, thus supporting the introduction of process innovations but not necessarily new products and services. In POIR, some of the more effective instruments from POIG were repeatedly included and further improved, so that the Programme offers a comprehensive portfolio of support measures, extending from research activities to market innovations.

3.5.2 Public procurement of innovative solutions

The Polish public procurement market in 2014 was worth €31.8 bn EUR (133,2 billion PLN). In around 80% of cases the price was the only criterion (UZP, 2015: 7). Many public sector organisations feared legal complications and therefore preferred to use the traditional public procurement scenario.

Legal public procurement framework

Even though no specific law regulates the pre-commercial procurement (PCP) procedures, the Act on Public Procurement of 29th January 2004 amended on 1st April, 2014 stipulates that the traditional public procurement shall not apply to contracts where the subject matter includes "research and development services and provision of research services, which are not wholly remunerated by the contracting authority or which results are not exclusively owned by the contracting authority" (Art. 4, 3.e). This measure follows the requirements exposed in the article 16f of the Directive 2004/18/EU.

The amendment simplified purchasing procedures at PHEIs and PROs, by freeing them from standard public procurement routes if the order value is lower than €207k. Public procurement regulations no longer apply to research services, results of which would be openly shared with the public. Moreover, public procurement results can be easily nullified if the organisation does not receive R&D funds, which were allocated to finance the order in question.

The 2014 amendments to the Act on Public Procurement were intended to encourage a broader use of qualitative criteria in tenders, but their actual impacts are not clear yet.

The new EC directives are still waiting for the full implementation (the deadline is April 2016). Selected elements of the new directives have been already transposed (e.g. the exclusion for grave professional misconduct). A draft of the new law has been already prepared but was not passed by the last government due to strong criticism. The new government works on updating the act.

PCP/PPI landscape

Poland has a formal action plan related to Sustainable Public Procurement (including Green Public Procurement, GPP) but the planned activities were restricted to information and promotion, without specific procurement targets or incentives for procuring organisations. The Polish Agency for Enterprise Development offers training and publications intended to improve the quality of public procurement procedures. The 2014 amendments to the Act on Public Procurement were intended to encourage a broader use of qualitative criteria in tenders, but their actual impacts are not clear yet.

No targets have so far been introduced to stimulate the use of innovative public procurement.

PCP/PPI initiatives

In July 2013, NCBiR launched a pilot project supporting the use of PCP, with an open call collecting proposals for socio-economic challenges, which could subsequently be addressed in a broad PCP process, with a budget of €12m. The project was intended to demonstrate the feasibility of PCP within the Polish legal framework and encourage other institutions to follow this example, but was received by public sector organisations with a rather limited interest. In the 2014-2020 perspective, public authorities will conduct small-scale experiments with PCP using the EU Structural Funds to target certain societal challenges. In 2016, NCBiR will launch a pilot project supporting the use of PCP (E-Pionier) with the objective of harnessing the potential of young innovative software developers with a total budget of approx. €25m till 2020.

More substantial examples of innovative procurement can be observed in the defence sector. A large pre-competitive procurement-type military R&D programme is co-ordinated by NCBiR, and calls for proposals address specific needs, expressed by the military organisations. The size of military budget is substantial and will amount to 2% of GDP in 2016, with a large part of the defence budget oriented towards orders from domestic R&I performers.

3.5.3 Indirect financial support for private R&I

Indirect financial support for business R&I is not popular in Poland, and most of the public funding for R&D is distributed in the form of subsidies, accompanied by financial instruments supporting innovative investments. Poland offers incremental tax exemptions related to the implementation of new technologies, targeting the acquisition of innovative technological solutions and related services from external entities. Regrettably, these exemptions stimulate technology imports and discourage in-house R&D. This feature of Poland's fiscal system differs from other EU countries, where tax regulations are used to stimulate intramural research efforts.

In 2014, only 80 business enterprises (0.018% of corporate tax payers) benefited from these exemptions, amounting to €67.821m, i.e. 0.935% of taxes paid by corporations (MF, 2014: 2, 14).

The numbers of beneficiaries and volumes of these exemptions increased in the recent 5 years (2009: 25 beneficiaries, €4.897m; 2010: 33 beneficiaries, €7.832m; 2011: 97 beneficiaries, €65.770m; 2012: 94 beneficiaries, €104.990m; 2013: 75 beneficiaries, €73.959m) (MF, 2010: 17; MF, 2011: 17; MF, 2012: 17; MF, 2013: 17; MF, 2014: 17), but plays only a marginal role in the domestic innovation system. These exemptions will be eliminated in 2016, based on the Act on Amendments of Some Acts with respect to the Support for Innovativeness, adopted in September 2015. Tax benefits are also available to formally approved R&D centres, but as of September 2015, the list only included 42 companies. Inconsistencies in the Polish approach to tax incentives for R&D have already been described in the sub-chapter 2.3. The government has been promising the introduction of dedicated R&D tax measures as soon as the excessive deficit procedure against Poland is terminated, but abandoned the plans in 2015 and refrain from referring to them in the National Reform Programme 2015-2016.

The Ministry of Economic Development grants financial incentives to large corporate investors, based on "Programme for the support of investments of considerable importance for Polish economy for years 2011-2020", partly subsidizing the costs of employing new, qualified experts. The subsidy is granted only if the beneficiary maintains a pre-determined size of headcount and invests a specific amount of own capital, greatly exceeding the size of the subsidy. Council of Ministers amended the support rules in 2014, strengthening the programme's focus on new R&D investments. The recent beneficiaries included: Cisco Systems, IBM, Fujitsu, ThyssenKrupp, Goodrich Aerospace, SolarWinds and Hispano-Suiza, and in previous year the scheme attracted also FDIs among others by: Nokia Siemens Networks, Tieto, Franklin Templeton, UniCredit, Samsung Electronics, Atos Origin, Citibank, Fiat, McKinsey, Umicore and Valeo, and the incentives were also offered to Polish food companies Pudliszki and MLEKOVITA as well as domestic software company UNIT4 Polska.

3.6 Business R&D

3.6.1 The development in business R&D intensity

The Polish BERD has a rather modest intensity (see figure 8 below), but the strong increasing trend from 2010 onwards is worth mentioning. The increases in BERD are matched by the increases in the employment of researchers and total R&D personnel in business, both indicators showing a positive growth from 2010.

It is also to be noted that the actual business R&D expenditures might be underestimated due to the lack of appropriate incentives for businesses to report them and/or qualify them as R&D costs (Kapil et al., 2012; EC, 2015: 23).

The recent changes in the tax qualification stemming from the Act on Amendments of Some Acts with respect to the Support for Innovativeness adopted in September 2015 introduce the definition of R&D efforts to the Polish tax accounting system and allow companies to classify parts of the R&D expenditures as tax-deductible costs as from 2016. This change is likely to further increase at least the reported R&D business expenditures in the next years.

Manufacturing and services alone account for more than 95% of the BERD expenditure in the period under scrutiny. The aforementioned growth of the total BERD intensity from 2010 is the result of their combined growth along that period. In the period 2010-2012 the BERD intensity in manufacture and services are rather similar, so they are roughly equally responsible for the growth of the BERD intensity in Poland.

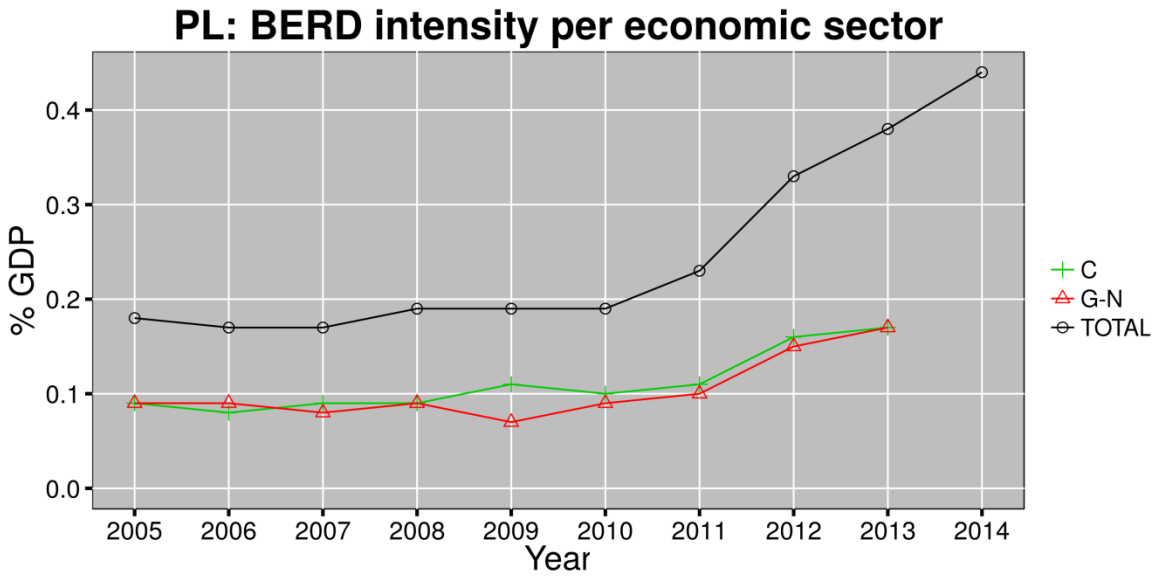

Figure 8 BERD intensity broken down by most important macro sectors (C= manufacture, G_N=services).

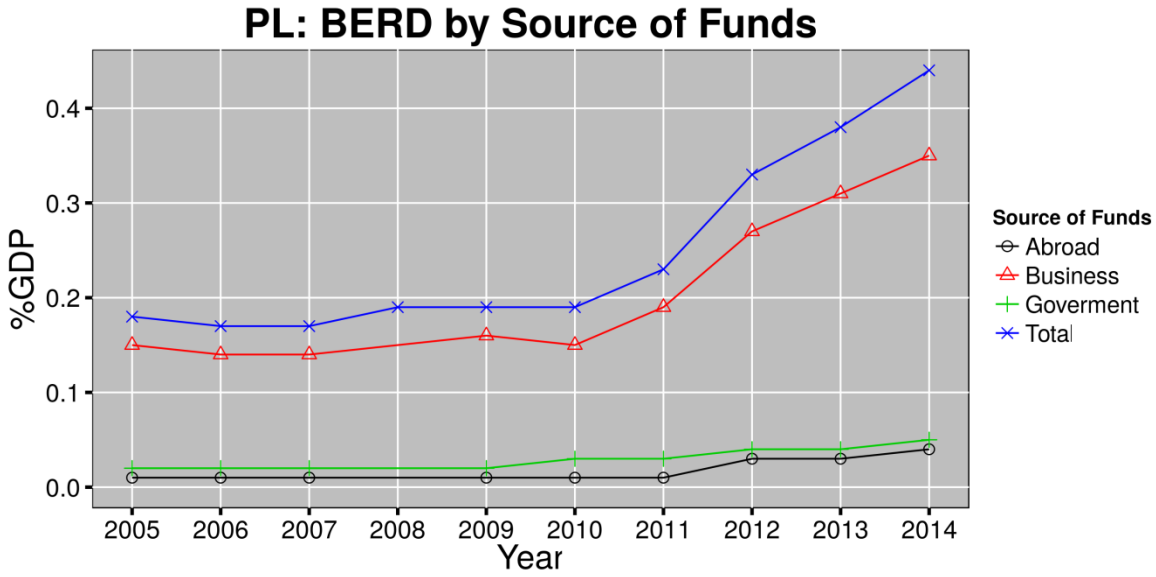

Figure 9 BERD by source of funds.

The private sector (see Figure 9) is the main funder of the Polish BERD. However, in the period 2010-2013, the gap between the business contribution and the total BERD tends to increase as a consequence of the rising, although modest, contributions from abroad and the government to the BERD.

The recent strengthening of the trend can be attributed the wide-ranging institutional reform of the R&D system that shifted the focus of the public funding to R&D. Most notably, the National Centre for Research and Development since 2010 leverages business R&D spending by introducing multiple grant programmes as public-private partnerships (e.g. BRIdge, CuBR). The principle is also used for sectoral programmes financed from the EU Structural Funds 2014-2020 (e.g. INNOMED or INNOLOT) which explains the partially the increase in abroad funding. In 2014, the average private co-funding from business enterprises in all programmes funded by NCBiR amounted to 23%.

The budgets of R&D projects implemented by companies using the NCBiR's support corresponded to 34.6% of BERD. The total private co-funding contributed by business enterprises was €197.36m in 2014.

What is more, the foreign-owned companies offer substantial R&D contributions and accounted for 45.76% of BERD in 2013 (GUS, 2015a). The R&D expenditures related to FDIs are rarely result of a relocation of existing R&D activities by foreign companies, but rather present greenfield-type investments in new technology development projects. The Polish government started actively attracting R&D FDIs in recent years. The government agency dealing with foreign investments, PAIZ, treats R&D investments as a priority, with focused efforts of PAIZ specialists interacting with potential investors, and the Ministry of Economy offers subsidies to prioritized FDI projects, based on the 'Programme for the support of investments of considerable importance for Polish economy for years 2011-2020'. The registered increase in R&D funding from foreign investors in 2012 proved to be significant. 2,467 business enterprises with 30,250 R&D employees declared R&D activities in 2013, and 45.76% of BERD was funded by enterprises with foreign capital.

3.6.2 The development in business R&D intensity by sector

The automotive sector (manufacture of motor vehicles) is one of the leading manufacture sectors in Poland. There was a spike of expenditure in this sector in 2009, followed by a sharp decline in the following year.

The BERD in the manufacture of electrical equipment has been on the rise since 2009, and it reached an unprecedented level in 2012.

The pharmaceutical sector is also an important sector in the Polish manufacturing landscape with several pharmaceutical R&D intensive clusters in the country.

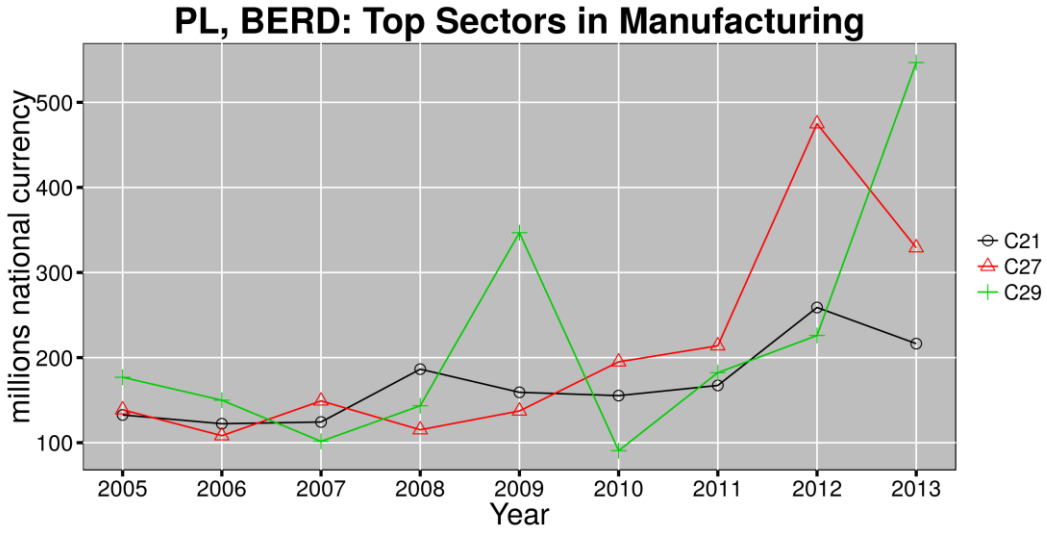

Figure 10 Top sectors in manufacturing (C21: manufacture of basic pharmaceutical products and pharmaceutical preparations; C27=manufacture of electrical equipment; C29=manufacture of motor vehicles, trailers and semi-trailers).

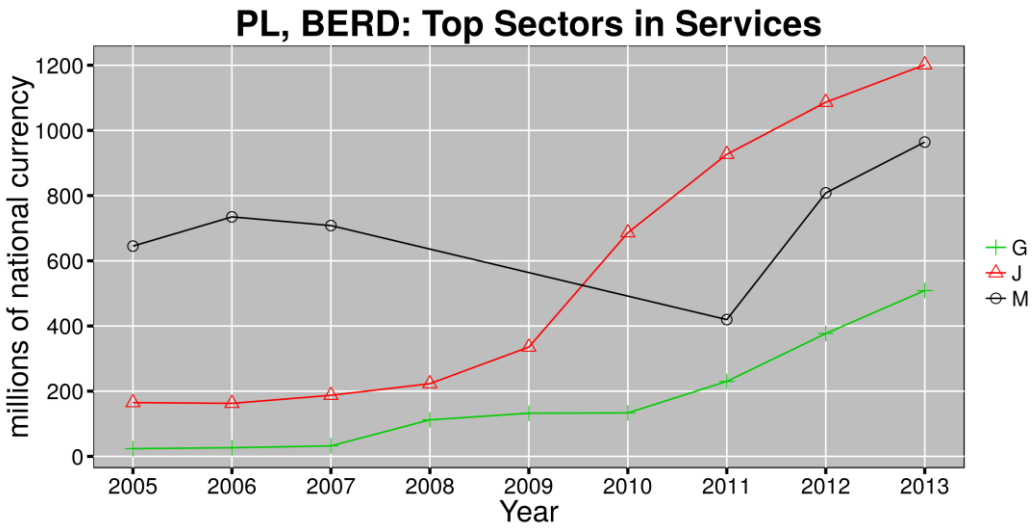

Figure 11 Top service sectors (G=wholesale and retail trade, repair of motor vehicles and motorcycles, J=information and communication, M=professional, scientific and technical activities).

As far as the services are concerned, the importance strong rise from 2009 of the information and communication services in Poland. This can be attributed to the important growth of supplier of advanced business services with both local investors and foreign capital creating and gradually upgrading the services to e.g. advanced IT programming, business research and analytics or supply chain logistics coordination centres. The total outsourcing and offshoring sector in Poland, grew three times faster than India's in recent years (McKinsey, 2015).

The service activities gravitating around the automotive sector also follow a clear growing trend from 2008 onwards.

There is only sparse data about the services concerning the professional and scientific activities, but there is an overall drop in the period 2007-2011 followed by a surge in 2012 which may be linked to the financial crisis and decreased propensity of business to spend on consultancy and marketing services as the increasing trend was picked up in 2012.

The biggest R&D spenders are: Fiat Auto Poland (automotive), Polish Defence Holding (formerly Bumar Group) - a state-owned defence sector company, Asseco Poland and Comarch (ICT companies) and Polpharma (a pharmaceutical company)[26].

3.6.3 The development in business R&D intensity and value added

When looking at the contribution of the various sectors to the total gross value added (GVA), manufacture and the services in the automotive industry (wholesale and repair of vehicles) play a leading role. Construction, transportation and real estate activities, which are not extremely important for the Polish BERD, are nevertheless among the top sectors in terms of GVA.

The scientific and technical services are instead an example of an economic sector prominent both in terms of BERD expenditure and GVA.

[26] Comp. Annex 3.

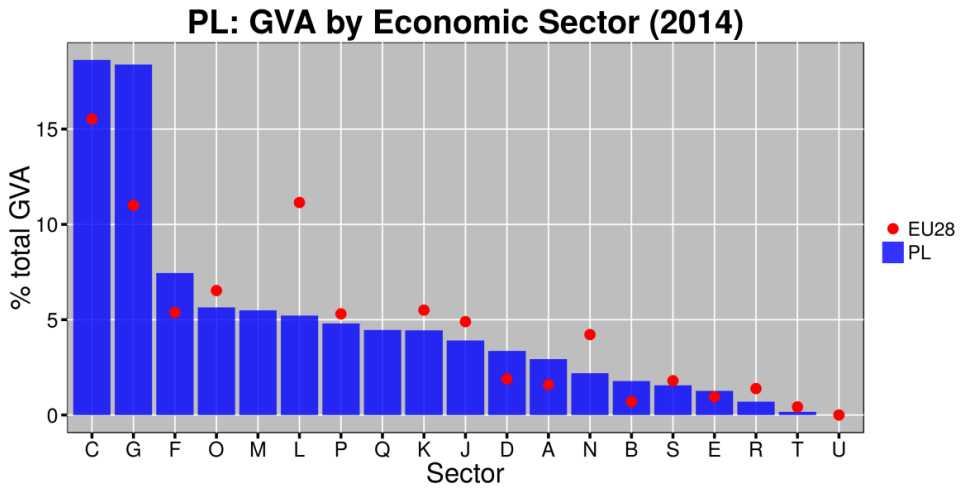

Figure 12 Economic sectors as percentage of the total GVA. Top 6 sectors in decreasing order: 1) manufacturing, 2) wholesale and retail trade, repair of motor vehicles and motorcycles 3) construction, 4) Public administration and defence; compulsory social security 5) professional, scientific and technical activities 6). real estate activities.

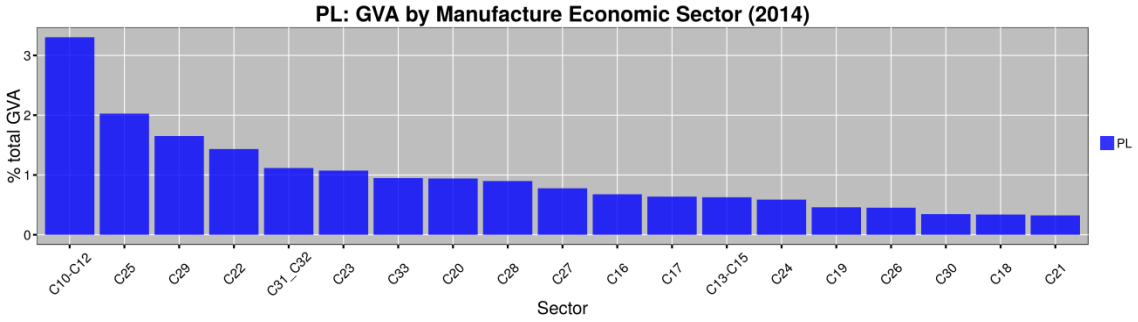

Figure 13 GVA in manufacturing. Top 6 manufacturing sectors: 1) manufacture of food products, beverage and tobacco products, 2) manufacture of fabricated metal products except machinery and equipment, 3) manufacture of motor vehicles, trailers and semi-trailers, 4) manufacture of rubber and plastic products, 5) manufacture of furniture, other manufacture. 6) manufacture of other non-metallic plastic products.

The manufacture of food, beverages and tobacco appears to be the leading manufacturing sector in terms of GVA. Consistently with its importance in the manufacturing in terms of BERD, the automotive sector (motor vehicles, trailers and semitrailers) appears as one of the most important sectors also when its contributions to the total GVA in manufacturing are considered). The manufactures of metal, plastic and rubber products are also important contributions to the Polish GERD in manufacturing, which shows that the economy still largely depends on low tech sectors.

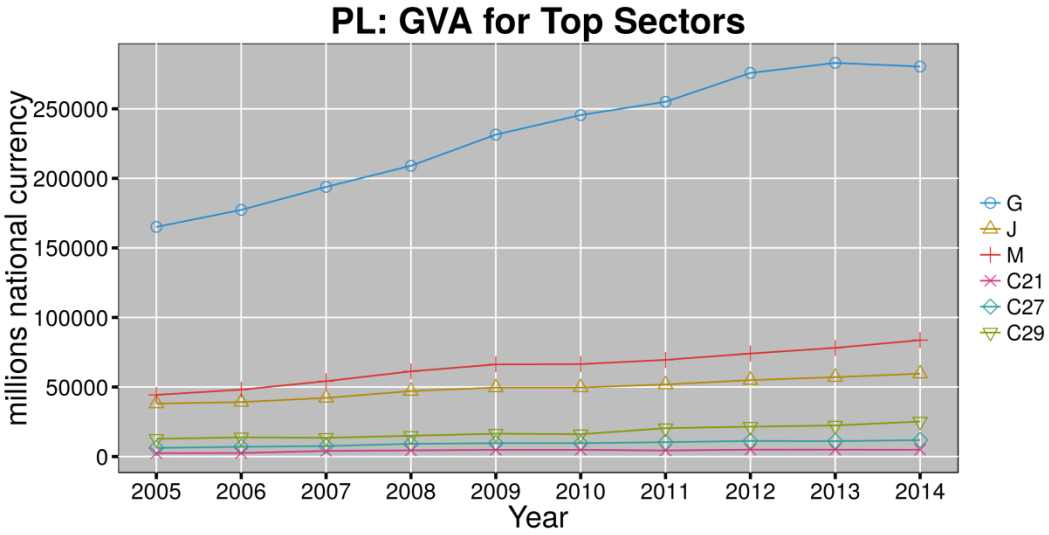

Figure 14 Value added for the leading sectors.

The above-presented graphs show that despite the high growth of the economy, Poland still experiences problems in arriving at a higher share of medium- or high-technology sectors (Bogumił, Wielądek, 2014). The structure of the Polish economy is one important explanation for the lack of R&D investments in the enterprise sector: the traditionally more R&D-intensive economic sectors (such as pharmaceuticals or electrical and optical equipment) play only a minor role in the GVA. The low and medium-low technology manufacture sectors are those contributing the most. The relatively high – compared to other industrial sectors – value added of low-tech sectors and, simultaneously, the relatively lower importance of the most R&D-intensive sectors in Poland can partially explain the low intensity of the Polish business R&D.

The R&D activity of Polish enterprises is on the rise with year on year increases in R&D expenses and growth in R&D personnel. The wide-ranging institutional reform of the R&D system commenced in 2010 and all policy measures aimed at leveraging business expenditure seem to have a positive effect on the Polish BERD. The recently introduced tax policy measures may further intensify this trend. Still, Poland made relatively little progress towards increasing the importance of medium and high-technology products and services and the traditionally more R&D-intensive economic sectors play less important role in the economy than the medium and low technology sectors compared to Hungary or the Czech Republic.

3.7 Assessment

R&I funding, distributed through competitive calls for proposals, is widely available in Poland, but the funding is focused on applied R&D and primarily offered to business enterprises. Scientists from PHEIs and PROs need to rely on fundamental research funding from NCN, and a small number of NCBiR's programmes, or liaise with companies as subcontractors or consortium members. This imbalance might restrict Poland's innovative potential in the future, but was intentionally implemented in R&I policies in 2013-2015 due to the assumption that public R&I investments will have the highest economic impact if the funded projects are managed by private sector entities, having financial motivations to succeed with the commercialisation of research results.

The use of competitively distributed project funding has been increasing since the 2010-2011 reform of science and higher education sector. The shares of institutional funding have dropped, thus reorienting PHEIs and PROs towards scientific productivity and competition.

Criteria for institutional evaluations, directly influencing the distribution of institutional funding, take into account standardized, quantitative measures (bibliometrics, financial values of grants and contracted research) but fail to incorporate qualitative assessments of scientific impact and research excellence. This has contributed to certain optimising behaviours of scientists and organisations, focusing on meeting quantitative targets (such as e.g. counts of articles published in journals with a sufficiently high impact factor) rather than deepening knowledge in a given field of research. At the same time, the nation-wide institutional assessments stimulated internal changes at PHEIs and PROs, highlighting the importance of research excellence and science-industry collaboration. Substantial funding is available to promising young researchers. When applying for project funding, researchers do not need to limit their plans to their present employers, as mobility is encouraged through the possibility of carrying out projects at other organisations. Regrettably, NCN's funding modalities, focused on fundamental research and disallowing support for applied R&D, discourage researchers at PHEIs and PROs from pursuing research initiatives directly addressing social challenges.

The positive aspect of the present R&I funding system is its ability to stimulate corporate R&I investments, as demonstrated by the past performance of NCBiR and the scale of private co-funding for the grants. The Centre's activities have substantially contributed to the increases in BERD and GERD registered in recent years, and the availability of well-targeted funding combined with relevant communication with potential beneficiaries, spurred the wave of interests in R&D even by organisations which have never engaged in such activities before. In 2013-2014, NCBiR dramatically shortened the proposal evaluation cycles, in a move much appreciated by business enterprises.

The available portfolio of direct financial support measures for R&I is extensive, covers various stages of the innovation cycle and has the potential to address societal challenges, particularly through science-industry collaboration. Regrettably, the sub-optimal design and limited availability of R&I tax exemptions restrict the innovative activities of the business sector, and encourage companies to make the launch of R&D projects conditional upon the award of R&D grants rather than to initiate such efforts merely due to business justifications, as the R&I performers could not recover parts of the incurred expenditures through indirect financial support in the future.

In addition, revolving instruments are greatly outnumbered by grants and thus inappropriately conditioning business enterprises, which expect the government to cover most of their risks in innovative projects.

A final concern is the expected decrease in R&I funding from the state budget in 2016, as the government starts relying heavily on the EU Structural Funds and implements proportional reductions of budgetary expenditures for the same purposes. Many previously available support measures have been supplanted by their counterparts, financed from POIR, and the proportion between public funding sources is likely to change.

4. Quality of science base and priorities of the European Research Area[27]

4.1 Quality of the science base

Poland's publication output is below the average EU levels with regard to multiple analytical dimensions, including: the numbers of publications per 1,000 of population (Poland: 0.92, EU: 1.43[28]), shares of publications with international co-authors (Poland: 28.4%, EU: 36.4%), percentage of highly cited publications (Poland: 6.38%, EU: 12.25) and shares of publications co-authored by representatives of public and private organisations (Poland: 1.1%, EU: 1.8%). Detailed statistics are presented in Table 8. The differences between Poland and the EU are heightened if the bibliometric data are compiled using fractional counting, i.e. affiliations of the first authors of publications are assigned higher weights than for co-authors presented on the second and subsequent positions, but the order of authors does not necessarily correspond to their decreasing inputs into the publications, and could also be alphabetical or disregarding the actual contributions but putting a representative of the most prestigious (and usually non-Polish) institutions first to increase the chances of publishing.

Compared with other Central and Eastern European countries, Poland generates similar quantitative publication outputs per 1,000 of population to Hungary and Lithuania, performs better than Bulgaria and Romania, but falls behind the other member states including Czech Republic, Slovakia and Slovenia. It also has the lowest share of international publications among all countries in the region. In 2010, only Bulgaria, Croatia and Romania had lower shares of publications among the most cited papers. The percentage of public-private co-publications in Poland, while smaller than the EU average, was relatively strong compared to other countries from the Central and Eastern Europe.

The bibliometric indicators have improved over time, as in 2000, only 4.83% of Polish publications were included among the top 10% most cited papers, while in 2008, the share went up to 5.38% and in 2010, these papers constituted 6.38% of Scopus-indexed papers. No newer data are available, but it might be expected that the science and higher education reform of 2010-2011 contributed to further improvements by stressing the importance of publishing in journals with high impact factors.

The Academic Ranking of World Universities 2015 includes only 2 PHEIs from Poland among top 500 academic institutions: University of Warsaw and Jagiellonian University, both occupying ranking positions between 301 and 400, but the University of Warsaw maintains a relatively stronger position in the subject field of physics (between 151 and 200).

[27] Contents of chapter 4 are partially based on ERA Communication Fiche 2013 for Poland (Klincewicz, 2013).
[28] Source: RIO elaboration of data derived from Elsevier Scopus database, including analytical reports by SciVal and Innovation Union Report.

Table 8 Bibliometric indicators, measuring the quality of the science base.

Indicator	Year	Poland	EU
Number of publications per thousand of population (full counting)	2013	0.92	1.43
Number of publications per thousand of population (fractional counting)	2013	0.75	1.22
Share of international co-publications (full counting)	2013	28.4%	36.4%
Number of international publications per thousand of population (full counting)	2013	0.26	0.52
Percentage of publications in the top 10% most cited publications (full counting)	2010	6.38	12.25
Percentage of publications in the top 10% most cited publications (fractional counting)	2010	4.20	11.41
Percentage of publications in the top 10% most cited publications (full counting)	2000-2013	5.39	11.29
Percentage of publications in the top 10% most cited publications (fractional counting)	2000-2013	3.46	10.55
Share of public-private co-publications (SciVal)	2011-2013	1.1%	1.8%
Public-private co-publications per million population (SciVal)	2011-2013	28.58	87.07

Source: JRC IPTS RIO elaboration on Scopus data collected by Sciencemetrix in a study for the European Commission DG RTD (Campbell, 2013). The share of public-private co-publications is derived from the Scival platform and is also based on Scopus data[29]. The data on public-private co-publications is not fully compatible with the data included in the IUS, due to differences in the methodology and the publication database adopted.

Recent attempts to improve the quality of the science base in Poland were described in chapter 2.2, among other R&I policy initiatives, and in chapter 3.4, when discussing the public funding for R&I. NCN allocates funding for basic research projects taking into account scientific excellence and publications in international, high-impact journals. The nation-wide institutional evaluation includes quantitative measures related to publication outputs and citation scores, and the criteria and modalities are further refined in 2015. The government invests a lot in research infrastructures, as it will be presented in chapter 4.2.2. Multiple support measures were intentionally designed to stimulate research excellence and relevance of Polish science in the international context, including POIR support measures no. 4.1.3 (virtual research institutes), 4.3 (international research agendas), 4.4 (R&D funding distributed by FNP with ERC-type programs), and extensive support for the participation of Polish researchers in Horizon 2020.

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4.2 Optimal transnational co-operation and competition

4.2.1 Joint programming, research agendas and calls

The Polish government actively supports the involvement of researchers in international R&D programmes, offering co-funding, information and specialist support. Poland allocates relatively high share of public funding to transnationally co-ordinated R&D initiatives: €44.48m in 2013, 3.09% of GBAORD, with the highest transnational R&D budget among all new EU members states (Eurostat, 2016). The amount is close to the transnational funding contributed by Denmark, and constitutes more than a half of Finland's transnational budget, outperforming all new Member States. Polish R&D performers start discovering benefits of this type of co-operation, demonstrated among others by the growing importance of the European Space Agency (ESA) since the first calls for proposals became available to Polish applicants in 2013. 16.1% of Poland's transnational budget was allocated in 2013 to Europe-wide transnational R&D programmes, 6% to bilateral or multilateral R&D initiatives, and the remaining funds to transnational public R&D performers (Eurostat, 2015). The situation in 2015 was different from earlier findings of JOREP (Joint and Open REsearch Programmes) report, describing the state of play in 2009-2010, which revealed that the Polish participation in European initiatives had been wider than the involvement in bilateral initiatives (JOREP, 2012: 20), but the national budget allocated had been significantly higher for bilateral projects than for European initiatives (JOREP, 2012: 21). The public budget earmarked for transnationally co-ordinated R&D went up by over 51% between 2010 and 2013 (Eurostat, 2014). The science and higher education reform from 2010-2011 facilitated transnational co-operation. Since the reform, transnational co-operation started playing an increasingly important role in the national science system, with the government offering co-funding for Polish participation in international initiatives, relying on results of evaluations of research proposals in international programmes and defining a national research infrastructure roadmap in line with the European efforts. Polish researchers benefit from standard procedures for receiving the co-funding, defined by legal regulations.

The funding agencies NCN and NCBiR stimulate the cooperation with information campaigns, co-funding and specialist support. Especially NCBiR is active in launching new co-funding streams. The support measures planned for years 2014-2020 (POIR) prioritize Polish involvement in trans-national initiatives. Poland participates through NCBiR and NCN in multiple initiatives, including JPIs and ERA-NETs, and allocates government budgets for co-funding Polish researchers. The joint calls are announced on websites of the R&D agencies and promoted by regular direct e-mail campaigns. The country maintains also bilateral cooperation programmes with Norway, Czech Republic, Israel, Japan, Luxemburg, Germany, Singapore, South Africa, Taiwan and Turkey (with co-funding managed by NCBiR or NCN). Jointly with the Czech Republic, Hungary and Slovakia (so-called Visegrad Group, V4), it maintains the Visegrad Fund, which supports among others co-operative R&D projects involving researchers from the four countries. In 2015, countries of the Visegrad Group launched also the joint V4-Japan Joint Research Program, co-funding R&D in advanced materials. Poland participates also through NCBiR in KONNECT – a transnational R&D initiative, involving applicants from South Korea, Belgium, Czech Republic, Germany, Slovakia and Turkey. In addition, NCN organizes a domestically funded programme "HARMONIA", which supports transnational research projects. According to the 2014 science budget report, NCN invested in 2014 €15.714m in "HARMONIA" and €0.265m in other international initiatives (MNiSW, 2015a: 132), while NCBiR spent altogether €13.486m as contributions to multiple transnational programmes (MNiSW, 2015a: 156).

The government maintains a central, national contact point for EU programmes (KPK) and a network of regional contact points, supporting applicants to programmes such as Horizon 2020 by information sharing and free advice.

The EU programme LIFE+ is supported in Poland by the National Fund for Environmental Protection and Water Management (NFOŚiGW), and the R&D programmes for business enterprises, including COSME and ESA are co-ordinated locally by the Polish Agency for Enterprise Development (PARP). In 2012, Poland joined the European Space Agency, and the first tenders for ESA projects were launched in 2013. PARP offers also financial support for business enterprises, participating in international R&I programmes. In 2014, MNiSW published the "Pact for Horizon 2020" and encouraged PHEIs and PROs to sign it, as signatories can expect additional government support when applying for funding and carrying out Horizon 2020-funded projects, in return committing to streamlining internal procedures to empower researchers and dedicate administrative resources to project management. Starting from 2015, PHEIs and PROs benefiting from Horizon 2020 funding can also receive an additional bonus paid by MNiSW ("*Premia na Horyzoncie*").

In the new financial perspective of 2014-2020, many support measures funded from POIR are aligned with the Horizon 2020 instruments, including scope of calls and evaluation criteria, and some other measures directly complement the EU-level programmes to ensure synergies between different funding sources (Klincewicz, 2015b). POIR includes measures, supporting the internationalization of Polish science through support for the creation of international research agendas, stimulating cross-border R&D by enterprises and research organizations and co-funding of Polish research teams participating in international R&D programmes. Nevertheless, no common ex-post evaluation procedures have been implemented so far. Polish researchers benefit also from standard procedures when applying for government co-funding in multiple European research programmes. The Minister of Science and Higher Education established in 2010 the programme "Ideas Plus", supporting the participants of the European Research Council competition "IDEAS", who did not qualify for funding from ERC, even though their applications scored high in the evaluation by ERC. NCN offers dedicated funding for international fundamental research projects, carried out with foreign partners based on individual arrangements, bilateral or multilateral agreements, which are not co-financed from other sources (programme "HARMONY"). Polish organisations act as co-location centres of two Knowledge and Innovation Communities (KICs) – KIC InnoEnergy and KIC RawMat, benefiting from government subsidies, and another community, Climate-KIC, maintains a regional centre in Poland.

The Act on Principles of Science Financing (2010) established the legal framework for joint financing of R&D with international partners, including eligibility of costs and reporting requirements, compliant with regulations on public finance. The Ordinance of the Minister of Science and Higher Education concerning the criteria and mode of award and settlement of funds for financing international scientific co-operation (2011) paved the way for using results of international peer-reviews in national funding decisions, with the particular focus on co-funding of Polish researchers in international programmes. The Ordinance of the Minister of Science and Higher Education concerning the conditions and modes of awarding public support for financing international scientific co-operation (2011) defined corresponding rules for business enterprises, ensuring the compliance with the European regulations concerning the public support for enterprises. For R&D programmes with applied research and development components, conducted by SMEs, the Ordinance of the Minister of Economy amending the ordinance concerning financial support offered by the Polish Agency of Enterprise Development linked to operational programmes (2011) applies.

Poland did not formally define national standards regarding jointly funded research, and the priorities, eligibility criteria, selection procedures, reporting requirements, composition of project budgets and funding rates vary depending on each programme, but for most transnational initiatives, NCBiR and NCN follow the rules, which had been externally defined for a given programme.

Transnational R&D has not been prioritised in Poland's R&I policies, and despite substantial funding allocated to such activities, they only play a marginal role compared with domestic research and well-targeted use of international partners in individual projects (for example, R&D-related support measures in POIR facilitate subcontracting parts of the project to foreign PHEIs or PROs, if IPRs are transferred to the domestically operating business enterprise).

4.2.2 RI roadmaps and ESFRI

The Polish R&D sector benefited from significant public investments in the development of RIs in Poland. The efforts were spearheaded by the legal framework, defined in the Act on Principles of Science Financing (2010), establishing open competitive calls for large R&D infrastructure investments. Several ordinances of the Minister of Science and Higher Education (2010-2011) earmarked parts of science budget for RIs, defined investment criteria, selection modes involving peer-reviews, and opened up the competitions to business enterprises as well. In 2011, the Ministry published the first version of the Polish Roadmap of Research Infrastructure (PMDIB), compliant with ESFRI standards and including investment projects, selected in a nation-wide competition. PMDIB was updated in 2014 and currently lists 53 projects, prioritized for public funding, including from POIR. PMDIB is aligned with ESFRI roadmap, but focuses on the national level, not Pan-European infrastructures and primarily focuses on the strengths of domestic research teams. Evaluation of projects proposed for PMDIB took into account contents of the ESFRI roadmap in order to avoid unnecessary duplications.

PMDIB consolidates the scientific potential, stimulates rational decision making about investments, encouraging cooperation and joint use of the funded RIs by multiple research organizations. Inclusion in PMDIB was set as a pre-condition for future funding from POIR. The list of 53 RI projects covers a very broad range of possible R&D themes and does not identify areas of specialisation in RI, but RI projects funded from POIR are also required to comply with the list of national smart specialisations (KIS).

PMDIB merely lists RI projects, recommended for future funding– therefore, it is not an actual implementation roadmap, as it lacks specific milestones, assigned budgets and other instruments, but multiple other R&I support measures make use of PMDIB as the source of priorities for RIs. The combination of PMDIB and dedicated financial instruments based on POIR and state budget could be considered a a multi-annual financial plan for RIs . In 2015, amendments to the Act on Principles of Science Financing ensured financial support for PMDIB, and financial commitments to European and international RIs are included planned in multi-annual perspectives in accordance with national public finance legislations, with funds allocated in the science budget each year.

Nevertheless, the highest level R&I policy document, the Strategy for Innovation and Efficiency of the Economy (SIEG, 2013) listed as one of objectives the further development of RIs based on the PMDIB. Funding for RIs included in POIR amounts to €452.9m for 2015-2020 (POIR support measure no. 4.2), and multiple other funding sources are also used for smaller investments, including the state budget and regional operational programmes. Infrastructure can also be funded as part of R&D projects, using funds distributed by the government agencies NCN and NCBiR.

The Ministry published an online map of existing research infrastructure investments in the Polish public science sector, which is searchable based on RIs project names, keywords and fields of research, thus facilitating the identification of the required RIs. As of September 2015, the map lists 2,843 RI projects, with the total value of €7,308.737m. A detailed analysis of past RI investments was provided by the Main Council of Science and Higher Education (RGNiSW, 2015a). The scale of research infrastructure investments in Poland is impressive and many scientific organizations benefit from specialist equipment, facilitating ambitious research initiatives. At the same time, the infrastructure is still being under-utilized, but the future focus on funding R&D projects based on the RIs might increase the applications.

The investments covered from the EU Structural Funds are also associated with complicated state aid rules, in some cases discouraging the use of RIs for cooperation with business partners or applied research projects. The lack of unambiguous legal interpretations concerning the possible use of publicly funded RIs used to influence the perceptions of scientists and R&D managers, and seemed to limit the actual use of the RIs investments. In 2013, NCBiR addressed this challenge by publishing online legal interpretations and offering tools that facilitate commercial uses of publicly-funded RIs. Subsequently, the Centre launched a dedicated project SIMS ("Science Infrastructure Management Support"), targeted at PHEIs and PROs that benefited from large public investments in RIs and need specialist legal and business consulting and training services. Amendments to the Act on Higher Education (2014) obliged PHEIs to prepare by-laws defining modalities of access to research infrastructures by third-parties, including business enterprises, and project SIMS helped many organisations define these internal rules. POIR support measures are expected to optimize the use of existing RIs for applied R&D projects, especially jointly with business enterprises.

The existing legal framework does not prevent foreign researchers from using the RIs in Poland, but at the same time, the number of measures promoting and supporting the use of infrastructure used to be very limited. At this stage of R&D system development, the motivation to share results of RI investments with non-residents seems to be relatively low, with the exception of R&D projects, which could directly benefit the host institution. The situation can also be attributed to the limited focus on science and technology internationalisation, as discussed in the following sub-chapter.

4.3 International cooperation with third countries

Internationalisation of science is an important element of Poland's R&I policies, but the approach is based on a very specific understanding of the international dimension of R&I practices. The relevant targets defined in plan of actions of MNiSW for 2015 are as follows: increasing the international contributions of Polish scientists (measured by publications of authors with Polish affiliations in Elsevier Scopus) and increasing the internationalisation of higher education and science (quantified as counts of foreign students in Poland and R&D projects involving international partners, funded by NCN through the support measure "HARMONIA", comp. Annex 4). The Ministry of Science and Higher Education prepared also a dedicated "Programme of internationalisation of the higher education" (MNiSW, 2015d), which encompasses education and research activities, describing existing support measures available to PHEIs.

There are no comprehensive plans for co-operating with selected third countries. Poland signed bilateral agreements with many countries, but their potential remains overwhelmingly unexploited. Research co-operation is focused on a small number of partner countries, with the most developed R&I systems. In 2013-2014, the Polish authors of scientific publications indexed by Scopus database collaborated mostly with researchers from USA, Germany, United Kingdom, France, Italy and Spain, but the top 20 countries co-authoring with Poland included also Russian Federation, China, Ukraine, Japan and Australia[30]. Several leading PHEIs have significant international exposure, e.g. 44.5% of University of Warsaw's and 39.0% of Jagiellonian University's publications from 2000-2009 were co-authored with foreign scientists (Klincewicz, 2012), but other PHEIs and PROs have more limited collaborative experiences. The co-authorship patterns correspond also to partnerships in international projects. Beneficiaries of NCN's programme "HARMONIA" collaborated mostly with researchers in the US, Germany, United Kingdom, France, Italy and Spain (NCN, 2015a: 69). In FP7, Polish researchers had the largest number of collaborative links with teams from Germany, United Kingdom, Italy, France and Spain (EC DGRI, 2015: 159).

[30] Source: own elaboration of data derived from Elsevier Scopus database, September 2015.

The major co-patenting partners of Polish inventors are from Germany, Sweden, France, Italy, Switzerland and the United Kingdom (EC DGRI, 2011: 188), but overall counts of patents with foreign co-inventors remain low.

Multiple initiatives are intended to increase the attractiveness of Poland for talented researchers or investors from abroad. As it will be explained in chapter 4.4 of this report, foreign researchers might find the Polish remuneration unattractive, but legal regulations facilitate the employment of foreigners at PHEIs and PROs. All positions at PHEIs have to be advertised in English at EURAXESS portal, as required by the Act on Higher Education (2011). Poland participates in the EU Scientific Visa Package and recognizes degrees awarded by countries-members of the Lisbon Recognition Convention. The amendments to the Act on Scientific Degrees and Scientific Title and Titles in the Area of Art (2011) allow scientific institutions to award the title of professor to researchers with substantial experiences in foreign R&I systems, without the need to hold Polish post-doctoral degrees (habilitations). The Act on Amendments of Some Acts with respect to the Support for Innovativeness, adopted by the Parliament in September 2015, allowed experienced foreign researchers to participate in formal scientific procedures in Poland, and opened up the domestic job market to foreign graduates of Polish universities and doctoral students.

In 2015, NCN launched a support measure "POLONEZ", financing employment of experienced, foreign scientists who decide to carry out their R&D projects at Polish institutions. Foreigners have also access to support measures available to local researchers, as long as they decide to relocate to Poland to conduct their project (comp. chapter 4.4.3).

POIR includes measures directly supporting international collaboration, involving scientific organisations (POIR support measure 4.3 – "International research agendas", complementing the Horizon 2020 "Teaming for excellence" initiative), innovation clusters (POIR support measure no. 2.3.3, "Internationalisation of key clusters") and individual business enterprises (POIR support measure no. 3.3.1, "Polish technological bridges"). Inventors are also encouraged to engage in international patenting by NCBiR's PATENT PLUS programme and POIR support measure no. 2.3.4, focused on IPR protection.

The instruments intended to attract foreign investors will be described in chapter 5.5, including the "Programme for the support of investments of considerable importance for Polish economy for years 2011-2020", which offers grants to investors in selected areas, including R&D centres. The Polish public administration (including MNiSW, MR, PAIZ, NCBiR and the Ministry of Foreign Affairs) carry out Poland's promotional campaigns, targeting among others study candidates, researchers and companies.

Poland has only limited involvement in the Strategic Forum for International S&T Cooperation (SFIC) and does not engage in the co-ordination of R&D co-operation between the EU and third countries on the strategic level. Within the BILAT project framework, Polish partners are engaged in projects: "KONNECT" (South Korea), "BILAT-UKR*AINA" (Ukraine) and "BILAT USA 2.0" (United States). Poland maintains joint R&D programmes with partners from outside of the EU, including: India, Israel, Japan, South Africa, Singapore, Taiwan and Turkey. The country has also numerous bilateral agreements concerning science and technology co-operation, but most of these collaborations are not actively pursued on the governmental level. It also participates in multilateral programme of R&D co-operation between the Visegrad Group countries and Japan and in "SEA-EU-NET" project (supporting co-operation between EU and Southeast Asian countries). No multi-annual roadmaps for international co-operation have been developed by Poland.

4.4 An open labour market for researchers.

4.4.1 Introduction

The Polish science sector gradually transforms itself towards a greater openness and a merit-based employment. The employment market for R&D employees at PHEIs and PROs is regulated, based on government legislations, but employing institutions enjoy a degree of autonomy, defining specific by-laws together with labour unions to implement approaches stipulated by the national legislation.

In 2009, almost 50% of researchers in the higher education sector had been employed by the same institution for more than 10 years (Deloitte, 2012b: 53), and over half of all researchers had open-ended (tenure) employment contracts (Deloitte, 2012b: 76). The share of foreign researchers was low, and most scientists were employed by the institutions, where they had completed their studies or received scientific degrees. The situation started gradually changing due to the science and higher education reform from 2010-2011, which promoted open, competitive recruitment of researchers and established fixed-term employment contracts with regular performance reviews. The shares of doctorate holders in a job not related to their doctoral degree or below their qualification in Poland for years 1990-2006 were 4.2% for doctorate holders in jobs not related to their doctoral degree and 2.5% for doctorate holders in occupations other than professional and managerial, being much better than for most other EU countries (Auriol, 2010: 14).

The recent economic crisis did not affect the Polish scientists. Contrary to the tendencies in many other EU countries, salaries in public R&D sector were actually increasing in recent years, including increases in 2014 and 2015. Nevertheless, PHEIs fear the negative demographic tendencies, as the decreasing numbers of students in the coming years are expected to impact the costs structures of universities and indirectly influence the ability to sustain the current population of researchers.

R&D personnel in Poland accounted in 2013 for 0.60% of the total employment in FTE (EU: 1.26%) (Eurostat, 2015). In 2012, there were 4.3 researchers per 1,000 employed persons (GUS, 2014a: 78), and the R&D employment ratios increased compared to previous years. Eurostat data for 2009 revealed that 98.33% of doctorate holders in Poland were employed. Unemployment of trained specialists (human resources for science and technology, HRST) was relatively low at 3.7% in 2014 (lower than the average EU rate of 4.5%), but has gradually been increasing since 2008, when it was only 2.7% (Eurostat, 2015).

4.4.2 Open, transparent and merit-based recruitment of researchers

Hard laws regulate career paths in public R&D organizations, and enforce the merit-based recruitment and promotion of researchers (the Acts on: Higher Education, Research Institutes and the Polish Academy of Sciences, from 2010-2011). Labour unions are active at universities and research institutes, participating in the regulation of recruitment and employment conditions. The Act on Higher Education (including amendments from 2011) strengthened the autonomy of universities, with independent recruitment processes, eliminating direct influences from government bodies, but at the same time set general principles, promoting the openness and competitiveness of recruitment. Job offers at the PHEIs have to be published online on websites of the university, the Ministry of Science and Higher Education and "websites maintained by European Commission – the European portal for mobile researchers, dedicated for the publication of job offers for researchers". Recruitment should be based on a formal procedure, adopted by a university in its statute, which is to be consulted with labour unions. The maximum length of each employment contract is 8 years, tenures are reserved only for the most experienced professors (but tenures were also granted to researchers who had permanent employment contracts before the Act on Higher Education from 2011 entered into force).

The Act prohibited employment of relatives as direct subordinates and enforced the requirement of filling all PHEI positions through open competitions. Corresponding regulations were included in the Act on the Polish Academy of Sciences (2010), with job offers published online, and recruitment procedures based on a formal procedure, adopted by the scientific council of an institute of the Academy, with the maximum length of each employment contracts being 8 years. The Act on Research Institutes (2010) also calls for job offers to be published online, and recruitment procedures to be based on a formal procedure, adopted in the statute of the institute. Based on three above-listed acts, employees of all public-sector R&D organizations undergo regular scientific performance reviews (professors - at least once in 4 years, PhDs and other researchers - at least once in 2 years). Employees and candidates have the right to appeal selection decisions and outcomes of performance reviews. The open recruitment is further facilitated by R&D funding agencies, as many programmes require applicants to ensure that at least some members of the project team will be identified through open recruitment procedures.

The Polish academic system heavily relies on the post-doctoral degree (*habilitation*), which is required to access independent research positions. However, the amendments to the Act on Scientific Degrees and Scientific Title and Titles in the Area of Arts from 2011 reduced this access barrier, as researchers with good career records within foreign research systems were allowed to be promoted to professors without the need to hold the habilitation degree.

The existing regulations contribute to the removal of barriers in recruitment, but several elements are still missing. R&D institutions are not obliged to clearly specify eligibility criteria for each position, publish details on the selection criteria and process, or inform about the composition of the selection panel. The modalities for establishing selection panels and the selection procedures are to be defined by individual institutions, and usually no external (national or international) experts are involved (the only exception being the highest positions of professor). National regulations do not define: minimum time period between vacancy publication and deadline for application; the scope of feedback that unsuccessful applicants can receive; rights to appeal against the decision. Lack of the above-listed elements is a significant shortcoming compared with the criteria for transparent, open and merit-based recruitment of researchers. Moreover, many PHEIs and PROs have learned how to circumvent the legal requirements to select the initially preferred candidate, e.g. a former doctoral student. These approaches are further complicated by the official requirement to treat recruitment procedures for new positions and extensions of previously existing employment contracts in the same way, thus discouraging scientists unaffiliated with the recruiting institution from applying and restricting their mobility. At the same time, younger researchers find it easier to develop academic careers and apply for R&D funding. A part of institutional funding, distributed by MNiSW to R&D institutions, must be allocated to R&D projects, publishing, conference or travelling expenses of researchers up to the age of 35, thus promoting these young researchers and ensuring the funding for their research. Legal reforms from 2010-2011 facilitated the transition towards independent research positions, as procedures for awarding the habilitation degrees were streamlined and safeguards included to make the process more transparent and merit-based. Several funding programmes of government R&D agencies are directly targeting young researchers, and skilled young specialists can actually benefit from more attractive financial opportunities than representatives of the older generation.

Salaries of scientists employed by PHEIs or PROs in Poland remain lower than in many other knowledge-based professions, and the difference between Polish and foreign research institutes is even higher, but the best researchers can benefit from attractive R&D budgets, distributed by NCN and NCBiR. Scientists benefit from foreseeable career tracks, with clear and transparent rules for awarding the habilitation degrees and professorships, and academic performance evaluations became wide-spread.

Nevertheless, Poland experiences an outflow of specialists: in 2009, 260,000 of HRST holding Polish citizenship were residing in other EU countries, making Poland the 4th largest supplier of skilled workforce after Germany, Italy and the UK. Within the entire EU-27, Polish specialists residing abroad accounted for 9.8% of all HRST migrating between the member states (Eurostat, 2013). Graduates of S&T studies might feel uncertain about job prospects in Poland, as only 2.0% of doctorate holders in engineering and technology continue working as researchers, and 12.64% of them were unemployed in 2009, while 70.26% of them have already experienced international mobility in terms of periods of training or work abroad (Eurostat, 2013). At the same time, shares of doctorate holders below their qualification for years 1990-2006 in Poland were: 4.2% for doctorate holders in jobs not related to their doctoral degree and 2.5% for doctorate holders in occupations other than professional and managerial, being much better than for most other EU countries (Auriol, 2010: 14). Figures available from Eurostat reveal that 58.58% of doctorate holders working as researchers changed jobs over the period of 10 years preceding 2009, and the share was relatively high figure compared with other EU countries. No official statistics for outward flows of researchers from Poland exist, but these flows are expected to be relatively high, with many scientists exploring career opportunities abroad, and the primary reason being the relatively low financial compensation. Nevertheless, an economy-wide survey conducted by a consulting company Sedlak & Sedlak in 2013 indicated that salaries of PhD holders in Poland were on average 18% higher than salaries of employees without this academic degree (Tryka, 2014), with the revealed disparities concerning most likely private sector organisations not academia.

For foreign researchers, language remains a possible barrier in recruitment processes - even though the Ministry of Science and Higher Education publishes an English translation of the list of job vacancies in public R&D organizations, most recruitment procedures require the submission of Polish-language documents. Additional barriers include relatively low salaries for researchers, and implicit preferences for own graduates in recruitment procedures. Poland remains a relatively unattractive country for foreign researchers, especially due to the limited employment prospects and comparatively low remuneration levels.

The Polish government tries to attract foreign scientists thanks to multiple support measures, including access to most R&D programs for researchers residing in Poland, the availability of programmes dedicated for international project teams at NCN and FNP, as well as a new funding programme "POLONEZ", introduced by NCN to fund salaries of leading foreign researchers relocating to Poland. However, funding available in the above-mentioned programs does not guarantee the necessary critical mass as it only affects a limited number of researchers. For foreign-based Poles, return mobility grants "HOMING PLUS" were offered by FNP in 2010-2015 based on the EU Structural Funds, but their continuation in the new financial perspective is uncertain.

4.4.3 Access to and portability of grants

Natural persons (including foreigners) can apply for projects at NCN (government agency funding basic research) and NCBiR (government agency funding applied research) without the need to be currently employed by a specific organization. For grant programmes, applicants can prepare "conditional" applications, including commitments of an organization to offer future employment and access to its infrastructure, once the application is successful. This promotes mobility and helps overcome obstacles, typical for researchers in earlier stages of their careers. Most grants are also available to foreigners, providing that the beneficiary institution will be in Poland. Researchers affiliated at foreign institutions cannot apply for grants, available to resident organizations, unless they decide to relocate to Poland to conduct the project, but some dedicated support measures targeting leading foreign researchers exist.

Portability of national grants in Poland remains limited, but recent measures aim at improving the situation. Poland did not adopt the principles of grant portability, defined in the EUROHORCs "Money Follows Researcher" agreement. The Act on Principles of Science Financing (2010) stipulates the award of funds for science primarily to organizations (and thus, can also be used by foreign researchers working at these organizations). In some cases, research grants can be ported to an organization selected by the researcher, who is not employed of this organisation, but only within Poland. Publicly funded R&D projects cannot be ported to institutions in other countries, except for dedicated funding programmes, which support international cooperation. The lack of support for cross-border portability of national grants might be interpreted in the light of limited availability of science funds in Poland and the current focus on increasing the effectiveness of R&D spending for the national system of innovations. Researchers benefit from intra-national mobility, but the existing science financing regulations prevent the outflows of public funds abroad, and intend to attract leading scientists to conduct their projects in Poland.

4.4.4 Doctoral training

Modalities and procedures for doctoral studies in Poland went through significant changes in 2011, based on several new legal measures. The Act on Higher Education (including amendments from 2011) set general conditions for offering doctoral studies, with requirements similar to other study cycles. Doctoral candidates were defined as students not employees, thus acquiring certain rights and obligations. The Act established a representation body of doctoral students and defined its role in decision-making processes at a university. It also enabled the launch of doctoral studies offered through inter-organizational co-operations, and introduced government scholarships for doctoral students. The Act on Scientific Degrees and Scientific Titles and Titles in the Area of Arts (including amendments from 2011) implemented transparent procedures related to the award of PhDs, allowing doctoral theses to be prepared in English and/or prepared and defended jointly at two institutions, including foreign universities. The Ordinance of the Minister of Science and Higher Education concerning doctoral studies and doctoral scholarships (2011) required doctoral studies to have formal programmes, with learning outcomes defined for specific study modules, and adequate quality assurance procedures. The Ordinance of the Minister of Science and Higher Education concerning the detailed mode and conditions for doctoral procedures, and procedures leading to the award of habilitation and professor's title (2011) detailed specific requirements from doctoral candidates to be awarded PhDs. The Ordinance of the Minister of Science and Higher Education concerning the documentation of studies (2011) introduced specific requirements concerning the documentation of studies, including doctoral studies, supporting the assurance of teaching and research quality. The Ordinance of the Minister of Science and Higher Education concerning conditions of programme assessment and institutional assessment (2011) defined criteria for the evaluations of study programmes, conducted by the Polish Accreditation Committee. These criteria include research performance, teaching and research infrastructure, co-operation with business, use of inputs from employers when defining learning outcomes, existence of teaching quality assurance system, existence of study programme with defined learning outcomes and methods for verifying their achievement. Universities should also monitor careers of graduates and establish internships with business enterprises. Even though the term "innovative doctoral training programme" is not explicitly used in Polish legislation, the formal requirements correspond to its principles. In 2014, the Minister of Science and Higher Education further emphasized the importance of improving quality and innovativeness of doctoral education, and announced the plans to stimulate the Ph.D. projects conducted in close co-operation with industry. The planned Operational Programme POWER (support measure no. 3.2 with €112.3m allocated for 2015-2020) will support the launch and delivery of innovative doctoral studies, with preference for interdisciplinary programmes, involving international researchers and science-industry collaboration.

An extensive analysis of the system of doctoral training in Poland, and the mobility of young scientists, was prepared by the Main Council of Science and Higher Education (RGNiSW), and included detailed data on relevant legal regulations and comparisons between models of doctoral studies in Poland and abroad, but did not include new empirical data collected through filed studies or surveys, and offered very general recommendations (RGNiSW, 2015b).

4.4.5 Gender equality and gender mainstreaming in research

Poland belongs to the EU countries with traditionally high shares of women involved in R&D activities, but despite the existence of equal opportunities for men and women in R&D sector, there is only limited support for career development of female researchers, who face the "glass ceiling" when trying to advance to higher positions, balancing family and work life.

The Polish Labour Code prohibits discrimination in recruitment and employment, and offers additional protection for women in the period of pregnancy and maternity leave (including ban on contract termination and guarantees of restoration to the same position after a maternity leave). The Act on National Science Centre (NCN) (2010) stipulates that periods of maternity leave and leave for taking care of children are not included in the calculation of maximum age for grants for young researchers. Corresponding regulations are introduced for NCBiR's program LIDER, dedicated for young researchers. Based on the ordinance of the Minister of Science and Higher Education concerning doctoral studies and doctoral scholarships (2011), the length of doctoral studies is also extended in a similar manner. Doctoral candidates in Poland are not regarded as employees but students, so are not covered by the nation-wide employment regulations. In 2015, MNiSW and the Ministry of Labour and Social Policy introduced a programme, targeting young mothers-students, Ph.D. candidates and university researchers. The programme, called "*MALUCH na uczelni*" ("TODDLER at the university"), offers co-funding for newly established nurseries at 43 PHEIs in Poland.

The Ministry of Science and Higher Education used to organize annual competitions "Girls of the future" for outstanding female researchers, in cooperation with the magazine "ELLE", with the intention to promote gender equality in research, but the most recent call was run in 2012. The Conference of Rectors of Polish Technical Universities manages a program "Girls on technical universities", compiling lists of "women-friendly" technical universities and establishing dedicated contact points for women. The international company L'Oréal with the support of UNESCO offers scholarships for women-scientists. The national monitoring of gender balance is conducted by the Central Statistics Office (GUS), which regularly collects data on employment, remuneration and scientific promotion of men and women. The implemented support measures are limited in scope, and concern only a small number of female researchers, so they could merely be perceived as awareness building activities. At the same time, general R&D funding programs do not pay attention to specific gender issues, without specific quotas for women or gender mainstreaming actions.

The existing measures focus on the removal of legal barriers related to the gender, but do not seem to adequately address the gender imbalance in decision making processes. They ensure equal treatment of men and women, but subject both groups to the same, competitive rules when applying for the scientific funding without gender mainstreaming actions (such as e.g. quotas for women in scientific boards or general R&D funding programs). The Act on Higher Education (including amendments from 2011) strengthened the autonomy of universities, and delegated the responsibility for defining formal recruitment procedures, adopted by the universities in their bylaws, which are issued with the involvement of labour unions. The composition of committees involved in recruitment and career progression is therefore defined internally by each R&D organization, and no evidence for specific gender mainstreaming actions was found. No laws exist concerning the preservation of gender balance in scientific program or project evaluation, with three notable exceptions.

The first is the composition of the Main Council of Science and Higher Education, which has advisory functions to the Minister of Science and Higher Education and consists of members selected from among the nominees of the science and higher education institutions. These nominations should take into consideration "the attempts to balance the share of women and men in the work of the Council" (The Act on Higher Education, amendments from 2011). Based on the same amendments from 2011, the Minister of Science and Higher Education appoints members of the Polish Accreditation Committee, ensuring that at least 30% of the Committee members are women (but as of 2015, there is only one woman in the four-person board of the Committee, and 2 female heads of teams for specific scientific disciplines, compared with 8 male counterparts). In 2009, the Minister of Science and Higher Education proposed a much broader introduction of gender-based quotas for scientific committees, but the legislations adopted in 2010-2011 turned out to be more conservative, and the above-listed examples of gender mainstreaming actions are limited in scope, while there are no prescriptions concerning the composition of scientific committees, involved in the selection and evaluation of projects at various funding agencies, or scientific promotion of researchers at public R&D institutions. The inefficiency of the existing regulations is reflected in the composition of the Main Council of Science and Higher Education: even though the law emphasizes the importance of balancing the share of women and men, among 32 members of the Council, only 6 are women (19%). The negative tendency continues also for scientific bodies appointed by the Minister of Science and Higher Education, where no gender-based quotas are prescribed by the law – e.g. the Council of Young Researchers includes 18 members, and only 5 are women (28%). The proportion of women as heads of higher education institutions in Poland was 13% in 2008 (latest available national data) (She Figures, 2009: 97), and women accounted only for 7% of members of boards in higher-education institutions and decision making bodies in the science sector in 2007, compared with the EU-27 average of 22% (Deloitte, 2012b: 42).

4.5 Optimal circulation and Open Access to scientific knowledge

4.5.1 e-Infrastructures and researchers electronic identity

The Virtual Library of Science, established in 2010, is the main ICT platform, supporting free access to scientific publications for researchers in Poland employed in a public research organisation. The project was implemented and is maintained by University of Warsaw, and funded by the Ministry of Science and Higher Education. Researchers and students of universities benefit from commercial publication databases, funded or co-funded by the government (depending on database). Unified logins are based on IP addresses of institutions, facilitating access to multiple electronic resources. A commercial project Index Copernicus was developed by a stock-exchange listed company IDH S.A., and offers a platform competitive to Web of Science and Scopus, with free basic access to data concerning the publications. NCBiR funded a multi-annual project SYNAT, which developed tools and platforms, supporting the establishment of open repositories of scientific publications and data for the use of all researchers and institutions in Poland. Multiple other, publicly co-funded projects support the improvements of e-infrastructures for R&D sector, and the scale of relevant investments is substantial. MNiSW maintains a central system POL-on, aggregating data about researchers, research infrastructures, publications and R&D projects of PHEIs and PROs. In 2015, NCBiR organised a call to fund the development and implementation of anti-plagiarism systems at higher education institutions, based on the EU Structural Funds (Operational Programme POWER, support measure 3.4). POIR support measure 4.2 will support the development of research infrastructures, including e-infrastructures in 2015-2020.

The largest PHEIs jointly manage a software house-type institution MUCI, which develops and maintains key ICT systems for the consortium members. MUCI delivers among others systems for managing studies, study registrations, archive scientific theses, perform anti-plagiarism verifications and centrally authenticate users from R&D sector. It is also involved in promotion of Eduroam service, currently widely available in Poland. Selected PHEIs and PROs form another consortium – PIONIER – delivering integrated network services to scientific institutions. PHEIs and PROs collaborate with major international suppliers to negotiate special terms for bulk licensing of popular scientific software and specialist databases.

Poland participates in the eduGAIN platform, supporting researchers' authentication and authorisation in partner networks. The electronic identity of researchers is partly implemented by Virtual Library of Science, which is available to all universities in Poland and helps log into multiple publication databases by means of institutional or individual authentication. The functionality has limited potential for tracking individual users or registering personal data. The developers of existing e-infrastructures do not pay particular attention to issues of personal data security, user tracking or privacy, but they need to comply with relevant national regulations in these areas.

4.5.2 Open Access to publications and data

Poland's policy regarding open access can be described as hybrid, but the actual support remains limited. For a non-weighted sample of articles indexed in Elsevier Scopus database, published in 2008-2011, 13% of publications with Polish affiliations were benefiting from "gold" open access (EU-28 average: 8%), and further 29% - from "green" or hybrid open access (EU-28 average: 37%) (Science-Metrix, 2013: 18). Importantly, some of publications included in the above sample had first authors coming from affiliations located in other countries, so the data do not necessarily represent conscious decisions of Polish researchers or funding institutions to support the open access. Preliminary analyses of the awareness and popularity of open access among Polish researchers indicate its rather limited impact. The exception is local peer-reviewed journals, published in Poland and included on the official list of MNiSW, which either offer full open access to its repositories (49.2%), use temporary access embargoes to contents of the newest journal issues (10.6%) or publish online contents of older issues (8%) (Szprot, 2014: 57). For Polish journals, the openness is linked to higher scientific status of the journals (Szprot, 2014: 65) and is also confirmed by the journal ranking system, introduced by MNiSW, but use of open access mode by Polish researchers, publishing in international journals, remains limited.

The availability of public co-funding for access to scientific publication databases obviated the need for wide open access debates, but the benefits concern only HEIs and PROs, not business enterprises. The Virtual Library of Science aggregates commercial publication databases into a common platform, licensed by the Ministry of Science and Higher Education for the use of researchers and students of all universities and research institutes. The services include unified login for multiple databases, based on IP address of an institution or login-based authentication, with easy addition of new databases. Many participants of the R&D sector are thus not aware of the restrictions associated with closed access publications, enjoying the contents of major commercial electronic libraries. At the same time, the Act on Industrial Property Rights (2000) guarantees the rights to use patented inventions for scientific, non-commercial research without the need to license the invention or pay royalties. Access to research data is difficult, as interested parties need to submit formal applications as stipulated by legislations concerning access to public information, and the applications can be denied by the research performers.

Poland participates in DRIVER (*Digital Repositories Infrastructure Vision for European Research*), and Polish institutions and scientific publishers are involved in many open access initiatives. Model agreement for applied R&D projects, funded by National Research & Development Centre (NCBiR) contains provisions, requiring beneficiaries to diffuse the project results by means of scientific conferences, academic journals, widely available databases guaranteeing open access to publications, and free or open source software. Since 2010, the Ministry covers fees for open access publications in Springer's journals (gold open access model), but the financial support concerns only this one publisher. In the same year, the National Programme for the Development of Humanities was established, and the grant programme includes a dedicated funding stream for electronic publications in foreign languages, implemented through regular, open calls for proposals. Ministerial programme „Index Plus" (2011) funds the digitization of scientific journals and for their electronic distribution. Examples of bottom-up initiatives, supporting open access in Poland, are: the Federation of Digital Libraries (managed by Poznań Supercomputing and Networking Centre, digitizing contents from Polish libraries, including scanned scientific publications), Centre of Open Science CeON (managed by University of Warsaw, aggregating free online publication databases and open access journals, offering legal advice, and maintaining open access repositories including CEON Repository and "Open the Book" repository of electronic books), as well as Index Copernicus. The initiatives adopt the so-called "green" model of open access, i.e. rely on voluntary self-archiving of publications by researchers. "Gold" open access can be supported by R&D funding agencies, if applicants include the costs in project applications, as such costs related to scientific publications are eligible in most R&D support programmes.

Amendments to the Act on Principles of Financing Science (2015) declared the availability of public funding to Polish scientific journals, which offer open access to their contents. In March 2015, the Ministry of Science and Higher Education established a team of experts, who prepared draft guidelines "The directions for developing open access to scientific contents" (MNiSW, 2015b), made available for public consultations in September 2015. The document contains recommendations to ensure open access to publications prepared based on public R&D funding, with NCN and NCBiR including relevant provisions in their funding agreements and tracking their implementation by beneficiaries. PHEIs and PROs are encouraged to establish institutional repositories, preserving scientific publications and to grant open access to research data.

The document does not have a binding legal status, and its contents are relatively vague, delegating most of responsibilities for specific action to R&D funding agencies NCN and NCBiR, without allocating any new funding dedicated to open access in international scientific journals.

5. Framework conditions for R&I and Science-Business cooperation

5.1 General policy environment for business

The RDI policy framework, established in recent years, considers business investment in research and innovation as a prioritized area. The policy documents: SIEG, PRP and POIR, as well as legislative efforts, have clearly articulated the needs to improve the enabling environment for innovations. The implementation of support measures for the 2014-2020 perspective is accompanied by ongoing organisational efforts to reduce administrative burdens, eliminate excessive bureaucracy. In the World Bank's ranking "Doing Business 2015", Poland was ranked 32nd, with only 13 EU member states ranked higher, and in the ranking's sub-category concerning the easiness of getting a credit by firms, Poland had the 17th position world-wide (World Bank, 2014). Public policies actively promote a favourable environment for SMEs, and many relevant instruments have already been presented in the sub-chapter 3.5.

Insolvency regulations support the financial reorganisation of troubled enterprises, and do not prevent unsuccessful entrepreneurs from attempting to establish new ventures. One of key policy documents PRP (Enterprise Development Programme) addresses the challenges related to insolvency, by promoting the currently available legal instruments among entrepreneurs and working towards a radical shortening of the existing, administrative procedures.

5.2 Young innovative companies and start-ups

Young, innovative companies can benefit from standard R&I schemes, helping them commercialize their ideas, and support measures in POIR have SMEs as primary targets. A detailed list of available support measures is presented in Annex 4, and they include support for all stages of the innovation cycle, including technology development, demonstration, first implementations, IPR protection and global expansion. NCBiR's GO_GLOBAL.PL programme supports the internationalization of innovative firms, by co-funding their co-operation with a technology accelerator from the Silicon Valley, US. The Ministry of Foreign Affairs through its embassy network organizes regular match-making meetings with potential partners, offering networking support for science-based companies, and the Ministry of Economic Development offers regular match-making events for selected geographical destinations (including the programme "Technology Bridge", establishing contacts between Polish innovative firms and partners from the Silicon Valley and other key international markets). NCBiR offers IPR support through its "PATENT PLUS" programme, and PARP supports the protection of IPRs by business enterprises based on POIR support measure 2.3.4, and will provide substantial funding to SMEs launching innovative products (POIR 3.2.1). Capital investments in innovative start-ups will be co-funded by POIR support measure no. 3.1.1, and a broad portfolio of financial instruments will facilitate investments of VCs, seed funds and business angels (comp. chapter 5.4).

Multiple dedicated measures facilitate the creation of spin-offs of PHEIs or PROs. NCBiR manages a programme "SPIN-TECH", which supports the establishment of the so-called "special purpose vehicles" (pl. *spółka celowa*), owned by PHEIs or PROs and intended to intermediate transactions with market participants and act as a holding company for individual spin-offs. SPIN-TECH facilitates valuation of IPRs and the use of other professional services, supporting the commercialisation. MNiSW offers a scheme "Innovation brokers", sponsoring the employment of sales professionals, who are expected to help PHEIs commercialise their technologies by either licensing or launching spin-offs.

These individuals not only receive regular base salaries, but also performance bonuses, with targets motivating to increase the number of transactions. MNiSW supports also young, successful researchers involved in applied R&D and technology transfer specialists from PHEIs and PROs within the framework "Top 500 Innovators", dispatching them for extensive training programmes at leading US universities, to deepen their knowledge of practical aspects of technology transfer processes. MNiSW offered also funding to PHEIS through its "Incubator of innovativeness" programme, facilitating the establishment of innovation incubators at universities to provide enabling environments and seed funding for spin-offs, as well as stimulate licensing of academic inventions to business enterprises. FNP SKILLS programme encompasses training in technology transfer ("SKILLS – Szkolenia"), coaching ("SKILLS – Coaching"), and funding competition for the most promising commercial ideas ("SKILLS – IMPULS"). In addition, MNiSW, NCBiR and the Polish Patent Office (UPRP) offer multiple guidebooks, brochures, online materials and trainings related to commercialization of research results.

Amendments to the Act on Higher Education from 2014 further facilitated the science-based entrepreneurship by empowering the scientists who could control the IPRs to their inventions. PHEIs were also obliged to define standard procedures related to assigning the IPRs to the researchers and to the commercial use of university infrastructure, which might be of particular importance for the spin-off companies. In order to support the creation of science-based spin-offs, NCBiR offers a set of programmes under the common name "BRIdge", including BRIdge Mentor (offering consulting services to scientists interested in science-based entrepreneurship), BRIdge Alfa (seed funding for scientific spin-offs) and BRIdge VC (VC funding for larger and more mature, science-based ventures).

ARP launched a knowledge transfer platform, acting as an intermediator between inventors or technology owners and implementing companies. The platform will be supplemented by a set of dedicated instruments, promoting open innovations (POIR support measure no. 2.2). Science and technology parks, technology incubators were supported by POIG, with instruments focused on promoting the establishment of new organisations in the years of 2007-2013, but in the 2014-2020 financial perspective, support will be focused on key institutions, with proven track record and consistent with the identified national or regional smart specialisations.

Public co-funding is also available for innovation clusters. An interactive online map of clusters in Poland is available online, with 187 clusters as of 2015. PARP regularly analyses and benchmarks the performance of these clusters. In recent years, the government was actively encouraging networking among organisations and formation of clusters, including by the support measures POIG 5.1, but only some of the established cooperative groups are deriving substantial benefits from the linkages. In the financial perspective 2014-2020, targeted public co-funding will be offered to "key clusters", identified in a nation-wide competition, to maximize the effectiveness of support (POIR support measure no. 2.3.3). NCBiR offers "sectoral programmes", supporting R&D initiatives defined jointly with a representation of an industry sector (cluster organisations or business associations).

A relevant example of non-government initiative supporting spin-offs is AIP (Academic Entrepreneurship Incubators), a network of incubators operating in most academic centres in Poland, open to students and scientists.

The Act on Amendments of Some Acts with respect to the Support for Innovativeness, adopted by the Parliament in September 2015, facilitated transfers of intangible assets to newly established companies, making such transfer tax neutral in 2016 and 2017 (i.e. the IP transfers carried out in these two years will not registered as direct sources of revenues or costs). This measure is likely to remove existing bottlenecks affecting innovative start-ups, but its short-term validity makes the future institutional arrangements uncertain.

5.3 Entrepreneurship skills and STEM policy

Insufficient practical skills of university graduates tend to be criticized by employers in various mass media publications. Polish universities implement traditional curricula, oriented towards the development of generic skills, knowledge and intellectual training. Many employers express preferences for less intellectually challenging education, which would be better targeted at job-related challenges. Many educators criticize these expectations and argue that the excessive focus on industry-specific skills would decrease the resilience of graduates and restrict their future job mobility, as technological and economic developments renders specialists in narrow fields unemployable. There are also substantial differences in quality of education between the leading PHEIs and multiple non-public higher education institutions, which were mushrooming in the 1990s but now are faced with adverse demographic trends and their struggles for recruiting and retaining students translated into lower academic standards, and subsequent dissatisfaction of employers.

After the 2010-2011 science and higher education reform, universities started re-modelling their curricula based on the "learning outcomes" approach (i.e. clearly defining the deliverables of courses and programmes, with specific knowledge items, skills and competences of graduates listed and verified). HEIs are also mandated by law to involve external stakeholders in the development of curricula and expected to further improve the quality of education. Compliance with these requirements is regularly verified by nation-wide accreditation procedures, obligatory for all higher education providers. Nevertheless, some PHEIs ensured only formal compliance with the legal requirements, related to the quality of teaching, without actually transforming their study programmes (adopted procedural changes not accompanied by attitude changes among lecturers).

In the period of 2007-2013, the EU Structural Funds were used to support the so-called "ordered specialties" - selected study programmes, identified as desired by employers and important for the national economy, particularly in the areas of science, technology and engineering. Analyses indicated mismatches between the actual expectations of employers and the educational offers, and in the upcoming programming period similar programmes will need to be jointly defined with the involvement of potential employers. The Operational Programme Human Capital (POKL, 2007-2013) offered also funding for various study programmes on graduate and postgraduate levels, as well as professional training, and MNiSW co-ordinated nation-wide competitions promoting the quality of teaching and innovative study designs. In the 2007-2013 period, the wide availability of additional public co-funding for selected study programmes had also negative effects by distorting the education market, and forcing some PHEIs to lower study requirements in order to complete their projects and receive cost reimbursements.

In the 2014-2020 perspective, the Operational Programme POWER supports organisations of corporate internships for university students (POWER support measure no. 3.1) and will also introduce other measures, targeting the development of practical skills, corresponding to the needs of the job market and promoting the excellence in education on various levels, instead of directly financing specific study programmes.

The Ministry of Infrastructure and Development conducted jointly with OECD a project *„Skills and competences for entrepreneurship"*, analysing the entrepreneurship training at PHEIs and recommendations developed in the project were taken into account while designing the new support measures for 2014-2020 (MIR, 2013b). POWER supports also the establishment of a "national qualification system", ensuring the comparability of employee qualifications, as well as the building of a unified "*register of [HR] development services*", intended to stimulate life-long learning. The register will increase the availability of publicly co-funded trainings for employees of SMEs, but no systematic, training-related voucher schemes or tax incentives for young SMEs exist in Poland.

5.4 Access to finance

5.4.1 Venture capital and business angels networks

Public co-funding, distributed by KFK (the National Capital Fund) contributed to the establishment of 17 venture capital funds, investing in innovative ventures. All of them were created with the involvement of experienced financial sector experts, and many involved also foreign investors. KFK contributed 50% of the initial capital, which was supplemented by the equal share of private funding. The overall capitalization of these 17 funds in 2015 amounted to €235m. The funds were carefully selecting investment targets, maintaining focus on specific types of technologies, sector and growth stages, with 118 transactions completed as of September 2015. After several years of preparatory work with potential investment targets, the funds started expansion of their operations as by 2014, only 26 had been concluded. These investments primarily concern ICT companies, with only several funded companies representing other industries. There are also many VC investments in innovative companies without the public co-funding component.

POIG 3.1 support measure was used in 2007-2013 to increase the availability of seed capital for early stage innovative firms through technology incubators. Another support measure, POIG 3.3.1, targeted potential investors (including business angels, investment funds), while POIG 3.3.2 co-funding was available to SMEs, supporting the contracting of specialist consulting and financial services to prepare companies for external investments. Support for financial investors, encouraging them to co-fund high-risk innovative ventures, will be continued in a similar form in POIR, taking into account results of evaluations of the past support measures and public consultations with the investing community.

POIR support measures no. 3.1 will facilitate investments in innovative companies, including: seed investments (POIR 3.1.1), specialists investment by business angels (POIR 3.1.2) and VCs (POIR 3.1.4).

In parallel, NCBiR launched a set of support measures called "BRIdge", intended to close the perceived funding gap for innovative technological companies with the involvement of VC funds. It attempts to offer a more systemic approach, which would stimulate larger scale private investments and corporate venturing. BRIdge Mentor prepares scientists for future commercialisation of their research results, including through the creation of spin-off companies, and the professional services are delivered by specialists from the leading consulting and investment firms. BRIdge Alfa focuses on seed funding, co-funded from public sources and involving experienced financial industry partners. BRIdge VC is in turn devoted to larger, more mature, but still high-risk investments. NCBiR works closely with VC specialists, and actively uses experiences of Israel's VC funds, which in the past were established with similar government support, and some share the experiences as BRIdge partnering companies. BRIdge programmes were under preparation for a long time, as NCBiR decided to initiate the process by issuing calls for proposals to identify the most appropriate VC partners, select only few of them and negotiate terms and conditions of investments before the instrument is open to potential applicant firms.

Apart from traditional VC activities, innovative companies in Poland can also benefit from the possibility of carrying out an IPO at a dedicated stock exchange market *NewConnect*, which targets small companies from technology industries, with less restrictive informational requirements compared with the main stock exchange listings. Investors at *NewConnect* include both individuals and financial companies, and for companies from industries such as biotechnology or ICT, the market proved a relatively easy way of accessing the capital necessary for growth. POIR support measure no. 3.1.5 offers SMEs access to professional services, related to the listing of shares at *NewConnect* or offering corporate bonds at a dedicated market called *Catalyst*.

160 business angels operate in Poland through 4 network organisations, and 38 companies financed by them in 2013 with a total investment value of €6.6m (EBAN, 2014: 5). Crowd-funding is also possible and relatively popular in Poland, but there are no dedicated legal regulations, offering specific protection of investors or encouraging such investments through fiscal measures.

The Industrial Development Agency (ARP) announced in November 2014 plans to establish its own VC arm, and will use POIR funding to support the establishment of an open innovations ecosystem (POIR support measure no. 2.2). Corporate venturing also occurs, both among foreign companies active in Poland, as well as among domestic players, e.g. the largest ferrous metal mining company KGHM initiated such investments already in 2013, the largest insurance company PZU announced its plans to co-operate with NCBiR on launching a joint technology investment fund, and multiple foreign companies such as Google and GE explore the opportunities to invest in technology SMEs.

Despite the wide availability of public co-funding for VCs, business angels and seed investors, no dedicated tax exemptions were available for individuals or organisations, interested in making financial investments in innovative companies. The availability of subsidies significantly reduces risks incurred by private investors, but at the same time, investment companies remain risk averse, and public funding might be crowding out private capital, inducing an excessive reliance on budgetary sources. In September 2015, the Parliament adopted the Act on Amendments of Some Acts with respect to Promoting Innovativeness, offering attractive tax incentives for smaller VCs, which would invest in R&D-intensive SMEs in 2016 or 2017. The regulation was intended to promote the growth of local venture capital and seed funds, encouraging them to invest in new technology-based firms by exempting their profits from selling shares or public listing of these SMEs.

SMEs can benefit from public credit guarantees, as well as dedicated support for exporting companies, including government trade missions, export programmes for specific destinations or industry sectors. In 2013, the European Investment Bank started offering credit guarantees for innovative SMEs in Poland, through their partner bank Pekao S.A. Most of the applied R&D support measures are available to SMEs and many are intentionally targeting companies not scientific organisations, with SMEs perceived as potential driving forces behind the commercialisation of research results. Financial instruments in POIR include: support for capital investments in BRIdge Alfa and BRIdge VC (POIR 1.3.1 and 1.3.2, altogether €438m), support for open innovations (POIR 2.2, €95m), set of measures distributed through financial intermediaries (POIR 3.1.1: investments in start-ups; POIR 3.1.2: investments by business angels; POIR 3.1.3: loans for innovative projects; POIR 3.1.4: VC support; altogether €442m), and bank guarantees for projects involving the implementation of R&D results (POIR 3.2.3, €121m).

The available portfolio of public measures supports the growth of start-ups and transition towards established companies, with dedicated instruments available at different stages of the cycle. In particular, POIR includes support measures enabling gradual development of SMEs, which intend to fill identified funding gaps, with the increased importance of revolving measures for more mature stages of the cycle.

5.5 R&D related FDI

The Polish government actively implements measures to attract R&D-oriented FDIs, using tax incentives, grants and outreach activities by the dedicated agency PAIZ (the Polish Information and Foreign Investment Agency). These measures focus on greenfield projects, while brownfield investments (foreign acquisitions of existing companies and repurposing of manufacturing facilities or laboratories) are not directly targeted by public policies and remain governed by market forces.

Foreign investors can benefit from tax benefits if establishing the operations in designated Special Economic Zones, spread across various regions of Poland. Projects with the highest added value for the national economy can also benefit from government grants, based on "Programme for the support of investments of considerable importance for Polish economy for years 2011-2020", and since 2014, the programme is focused on attracting R&D investments, quantified in terms of employed specialists and amounts of invested capital. FDIs can also benefit from R&I support measures available to all business enterprises operating in Poland. In previous years, FDIs in Poland were less R&D intensive – the World Bank estimated that the R&D-oriented FDI corresponded only to 4.5% of the total FDI volume in Poland in 2010, compared to 13% in Hungary and 21% in Slovakia (Kapil et al., 2012: 3), but the situation has improved after the reorientation of government policies.

In 2014, Poland was one of top 5 EU destination for FDI (fDi Intelligence, 2015: 8), moving up by 4 places compared with 2014 (fDI Intelligence, 2014: 6). PAIZ successfully completed 54 foreign investment projects in 2014, most of which represented advanced manufacturing, with 6 large investments in R&D centres. In the first half of 2015, out of 179 investment projects in PAIZ's pipeline, 17 were planned R&D investments with a total value of 60.64m and concerning 1,900 new employees (PAIZ, 2015a). PAIZ maintains the updated list of foreign investments (PAIZ, 2015b). Foreign-owned business enterprises accounted for 1.20% of GERD in both 2011 and 2012, and the share went up to 1.96% in 2013, corresponding to 45.76% of BERD (GUS, 2015a). The data on R&D of foreign affiliates, collected by GUS based on annual R&D survey, differ from the data available from Eurostat[31]. Polish national statistics indicate that foreign-owned enterprises spent on R&D corresponded to €388.22m in 2011, €525.14m in 2012 and €687.86m in 2013. In comparison, Eurostat data on R&D investments of foreign affiliates in Poland only account for €196.4m investments for 2011 (including €121m from EU-27, and €75.4m from outside of the EU, with the largest R&D-funding country being the United States: €60.9m, followed by the Netherlands: €29.8m, France: €20.8m and Germany: €19.4m, and with only minor R&D investments coming from Japan: €1.3m and the United Kingdom: €0.7m).

5.6 Knowledge markets

The existing regulatory framework, supporting the intellectual property rights, offers robust protection on the national level, but legal enforcement, including IPR infringement suits, is rarely used. Poland's IPR protection system relies on administrative registrations of patents, utility models, industrial designs and trademarks, with extensive examination of patent applications. Polish residents have the legal obligation to file their priority patent applications in Poland, but actually no sanctions prevent them from initiating the procedure abroad. Since no patents for software or business methods can be awarded in Poland, some inventors decide to initiate their patenting procedures at USPTO or EPO. The Polish law foresees a research exemption, according to which no patent licences are needed to exploit a patented invention for the purposes of further research. No formal registration procedures exist for copyrighted works, including software and databases.

[31] Data series "fats_g1b_rd" for 2011: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=fats_g1b_rd&lang=en, access date: September 2015.

In 2013 and 2015, the Polish Patent Office carried out extensive evaluations of its patenting procedures and opinion surveys of SMEs and other patent holders, attempting to improve the internal organisation and raise the numbers of patent applications. Over the recent years, the Office eliminated most of its backlog, significantly shortening the patent award cycles.

Costs of patent application in Poland are very low (€120 per application), and do not correspond to the actual patent examination costs. Inventors can also benefit from public subsidies to cover costs of international patenting (with multiple funding options, including: PATENT PLUS programme of NCBiR; POIR support measure no. 2.3.4 of PARP; eligibility of expenditures on IPR protection in most of applied R&D funding streams). In many publicly co-funded R&D projects, patent applications belong to typical project outcomes, committed by the beneficiaries. The Polish Patent Office organizes regular promotional and educational events, including conferences, seminars, exhibitions, targeting business enterprises and academics. It also coordinates a regional network of patent information centres. R&D partnerships between private and public organizations and IPR protection are also actively promoted by government agencies.

In spite of these activities, business enterprises in Poland use patents in a limited manner only, often regarding them rather as a marketing tool than source of legal protection. IPR enforcement might be problematic, as no dedicated IPR court exists in Poland, judges and prosecutors have only limited competences related to IPRs, and relevant proceedings concern mostly trademark and online copyright infringements. Companies tend to rely on trade secrets, which are regulated by the Act on Combating Unfair Competition. Even among companies listed on the NewConnect stock exchange, a market dedicated for innovative companies, only a small percentage of firms hold patents.

There have been cases of "stick licensing", in which large international companies used local law firms to mass-distribute letters threatening to sue recipient organisations for alleged patent infringements, even though no details of infringed patents were provided. Such cases involved some well-known and otherwise reputable technology companies, and had negative impact on the perception of IPRs among the domestic business community. Many society members represent anti-IPR attitudes, as evidenced by mass protests against the ACTA agreement in 2012 and protests of major industry associations against Polish plans to join the unitary patent system. It seems to be a Polish paradox that a disproportionally high share of patent applicants come from PHEIs and PROs, not always interested in commercialisation, as the counts of patents awarded to a scientific institution are used merely as one of important measures in institutional assessments, determining the level of R&D funding.

The Polish Patent Office has bilateral agreements with US, Japan and China (patent prosecution highways) facilitating patent filings in the respective geographical areas. Poland decided to opt out of the unitary patent system and the Unitary Patent Court to protect its domestic industry from the expected influx of foreign patents, based on conclusions from an impact assessment study, which outlined the expected, prohibitive costs for the Polish economy (Deloitte, 2012a). Poland, Czech Republic, Hungary and Slovakia agreed in 2015 to establish the Visegrad Patent Institute, which will act as search and preliminary examination authority under the Patent Co-operation Treaty, facilitating international patent applications and offering services at lower cost than the options currently available in the WIPO system. This transnational co-ordination of IPR activities follows the successful experiences of the Nordic Patent Institute in promoting the increase of international patenting by applicants from the Institute's member countries.

The Polish official statistics lack reliable information on technology licensing. The Central Statistical Office compiles licensing data collected through annual surveys, but they do not cover all types of licensing transactions or organisations, especially when licensing is combined with purchases of technological products or accompanies more complex transactions.

Many business enterprises are active in transactions related to trademarks, as this type of licensing can easily be used to transfer profits through shell-companies and reduce tax burdens in Poland. A new, publicly sponsored IP trading platforms was established by ARP in 2015, and POIR support measure no. 2.2 is directly focused on investing in IP, with multiple other support measures taking into account IP and intangible assets.

MNiSW established in 2013 a funding programme "Innovation brokers", covering salaries of technology transfer specialists at PHEIs to encourage licensing of university-generated IP. The same year, NCBiR launched a programme "SPIN-TECH" to stimulate the establishment of spin-off companies at PHEIs and PROs, including covering the costs of IP valuation services to transfer the IP to the newly founded entities. IPRs related to results of most of the publicly funded programmes are assigned to R&D performers, and the funding agencies do not preserve partial ownership or control over the subsequent commercialisation decisions. Amendments to the Act on Higher Education from 2014 further simplify the IP-based transactions, by allowing academic inventors to own patents to their inventions, so that they could engage in the licensing and sales transactions without restrictions typical for publicly funded organisations. In the financial perspective 2014-2020 (POIR), public co-funding related to IPR extends beyond mere patenting, covering also relevant consulting services, facilitating commercialisation and IP-based transactions.

The Act on Amendments of Some Acts with respect to the Support for Innovativeness, adopted by the Parliament in September 2015, facilitates the transfer of intangible assets to newly established companies and eliminates tax for such transactions in the years of 2016 and 2017. In these two years, dynamic growth of knowledge markets could be expected due to the favourable regulation.

5.7 Public-private cooperation and knowledge transfer

5.7.1 Indicators

Funding: Publicly-performed R&D funded by business enterprises

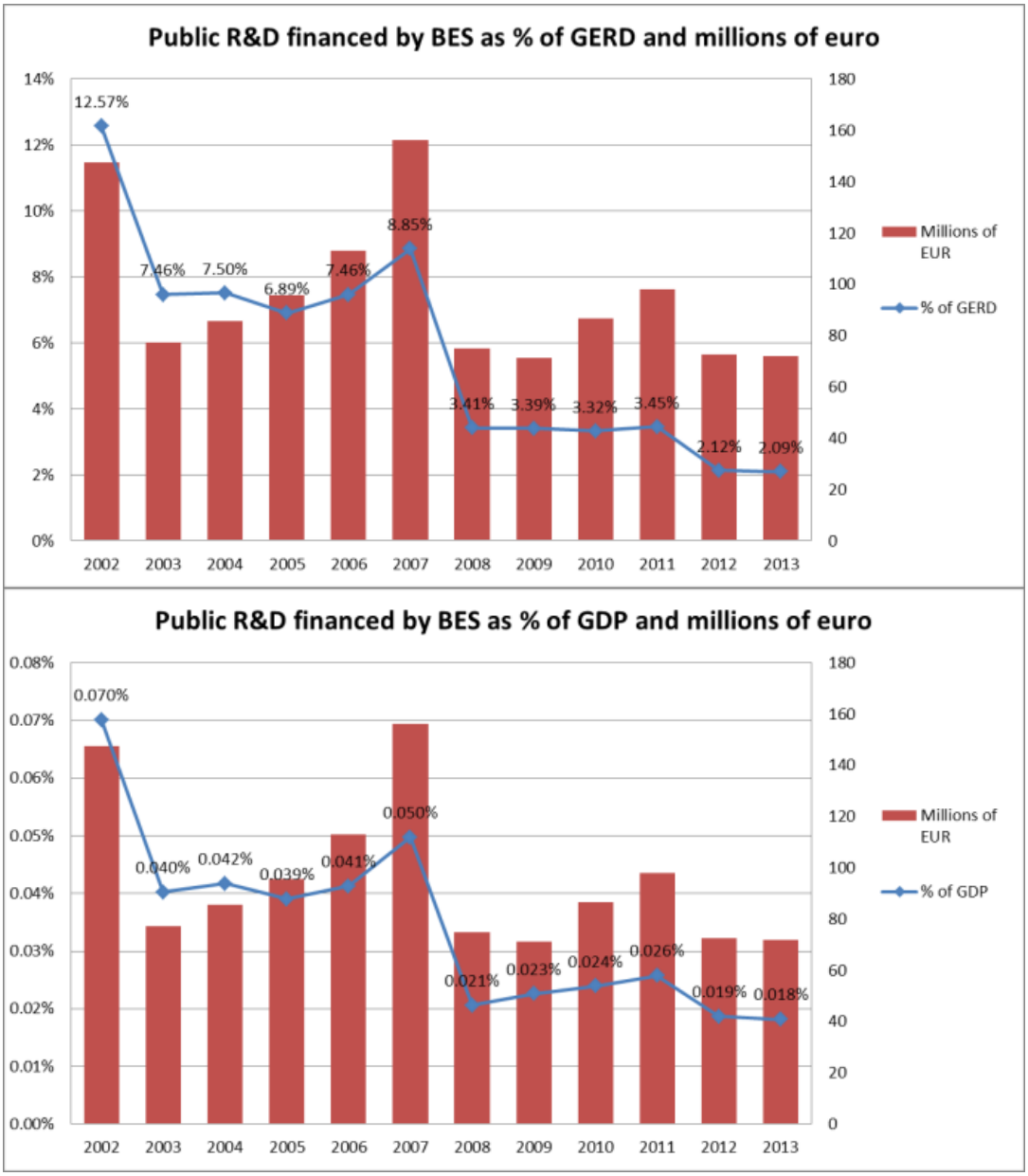

Figure 15 BES-funded public R&D in Poland as % of GERD, in €m and as % of GDP.

The level of the Polish business enterprise (BES)-funded public R&D expenditure as a percentage of GERD and in nominal terms decreased sharply in 2003 (from 12.57% to 7.46% of GERD and from €150m to 80). It was followed by an increase between 2003 and 2006 in nominal terms to decrease again in 2008 (from 8.85% to 3.41% of GERD and from €160m to 80). In 2007-2011 the expenditure experienced a period of a moderate increase in nominal terms and oscillation around 3.3-3.4% of GERD (2009-2011) to decrease once more albeit slightly in 2012-2013 both in nominal terms and as % of GERD.

The indicator expressed as a percentage of GDP shows a similar trend with sharp decreases in 2003 and 2007.

The low level of this indicator as from 2011 despite increasing BERD may be linked to the increasing focus of the national policy on science-business collaboration and the crowding out effect of the policies that fund this collaboration. As for previous decreases the may be linked to the general slow-down of the economy in 2003 and 2008-2009 that could have limited the business investment in contracted research.

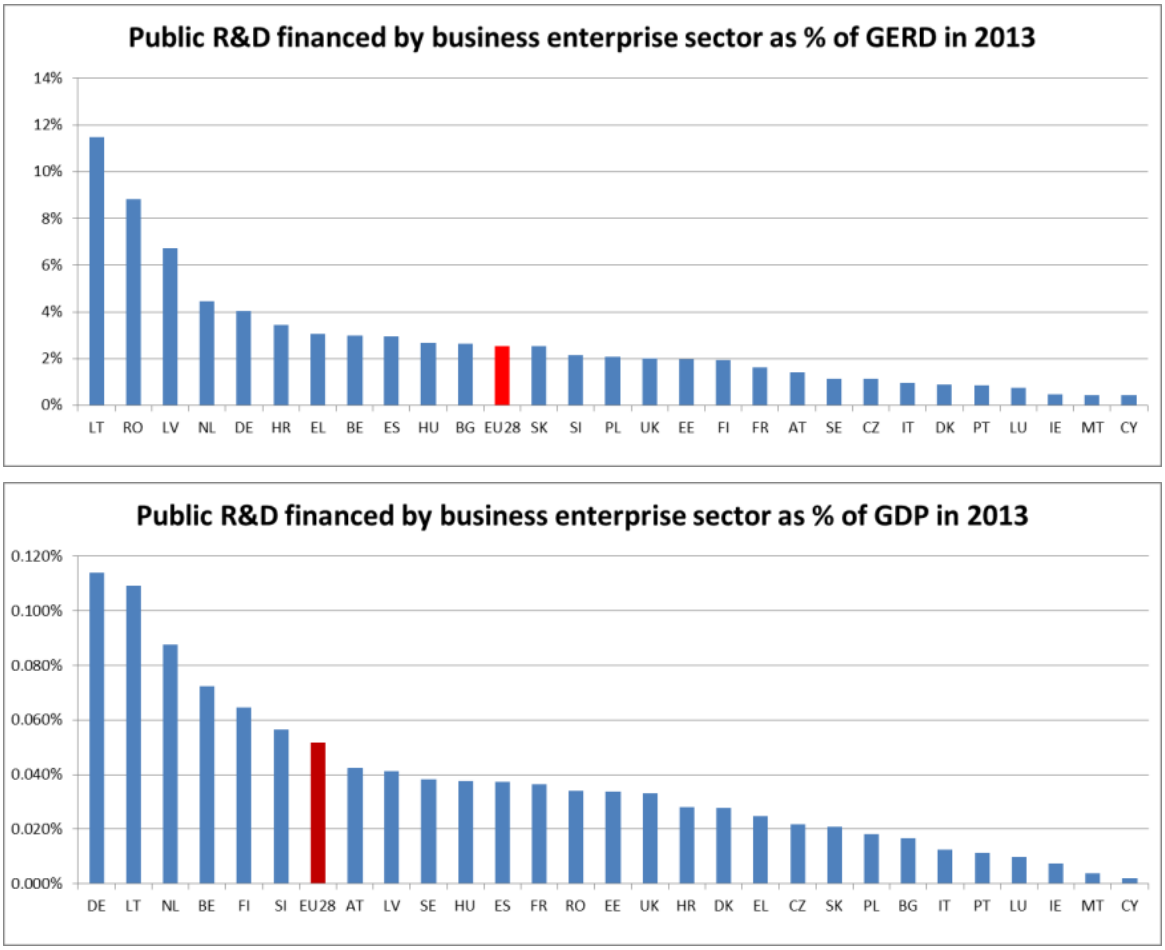

Figure 16 BES-funded public R&D as % of GERD and as % of GDP in 2013 in Member States[32].

The two charts in Figure 16 show the values of BES-funded public R&D in all EU-28 as percentages of GERD and GDP respectively.

Poland's levels are far below the ones of the best performers and slightly below the EU-28 average if expressed as % of GERD. As % of GDP Poland is at the far end of the scale which is due to the still moderate R&D intensity of the Polish economy.

The generally low level of the privately funded public R&D has several reasons, the main being the fact that R&D is mainly performed by large companies and therefore in-house rather than outsourced to the academia.

The Polish SMEs tend to prefer short-term goals and activities aimed at immediate return of investment (hence the popularity of technology adoption rather than technology transfer). On the supply side, the academia is slowly gaining competencies in R&D commercialisation and until very recently was not incentivised to look for new sources of financing as the public research evaluation system was not taking into account the knowledge transfer results.

[32] 2013 was chosen as the latest data series providing a full comparison within EU-28.

Funding: EU Structural Funds allocated for knowledge transfer

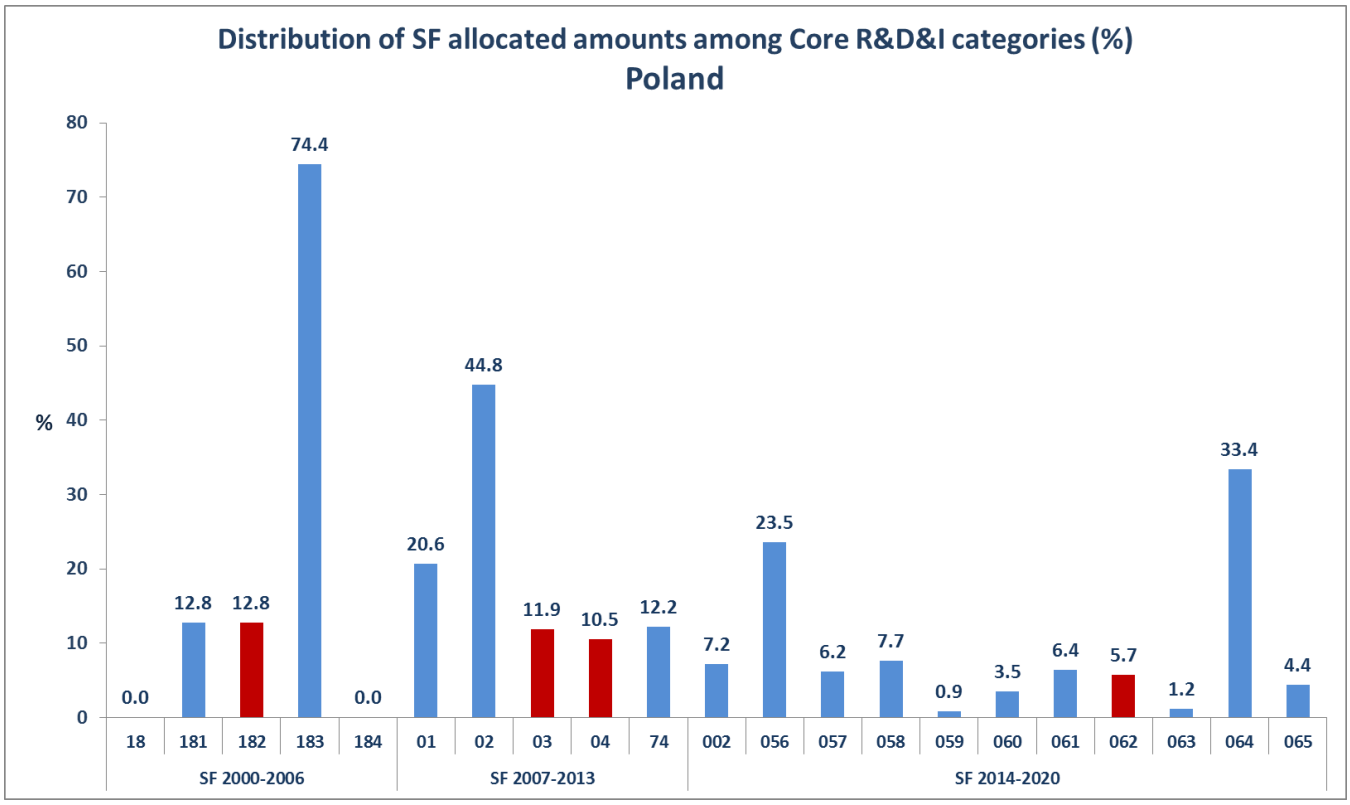

Figure 17 EU Structural Funds for core R&D activities 2000-2006, 2007-2013 and 2014-2020[33]. For allocations related to knowledge transfer, the categories are used: 182 (2000-2006)[34], 03 and 04 (2007-2013)[35] and 062 (2014-2020)[36] as proxies for KT activities.

Poland has allocated 5.7% of its EU Structural Funds for core R&D activities to "Technology transfer and university-enterprise cooperation primarily benefiting SMEs" (compared to 12.8% for 2000-2006 and 22.4% in the 2007-2013 programming period).

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[33] Figure 17 provides the Structural Funds allocated to Poland for each of the above R&D categories. The red bars show the categories used as proxies for Knowledge Transfer. Please note that the figures refer to EU funds and they do not include the part co-funded by the Member State.

[34] The categories for 2000-2006 include: 18. Research, technological development and innovation (RTDI); 181. Research projects based in universities and research institutes; 182. Innovation and technology transfers, establishment of networks and partnerships between business and/or research institutes; 183. RTDI infrastructures; 184. Training for researchers.

[35] The categories for 2007-2013 include: 01. R&TD activities in research centres; 02. R&TD infrastructure and centres of competence in specific technology; 03. Technology transfer and improvement of cooperation networks; 04. Assistance to R&TD particular in SMEs; 74. Developing human potential in the field of research and innovation.

[36] The categories for 2014-2020 include: 002. Research and Innovation processes in large enterprises; 056. Investment in infrastructure, capacities and equipment in SMEs directly linked to Research and Innovation activities; 057. Investment in infrastructure, capacities and equipment in large companies directly linked to Research and Innovation activities; 058. Research and Innovation infrastructure (public); 059. Research and Innovation infrastructure (private, including science parks); 060. Research and Innovation activities in public research centres and centres of competence including networking; 061. Research and Innovation activities in private research centres including networking; 062. Technology transfer and university-enterprise cooperation primarily benefiting SMEs; 063. Cluster support and business networks primarily benefiting SMEs; 064. Research and Innovation processes in SMEs (including voucher schemes, process, design, service and social innovation); 065. Research and Innovation infrastructure, processes, technology transfer and cooperation of enterprises focusing on the low carbon economy and on resilience to climate change.

It is much lower than the EU average of 15.7% (the EU average was 26.1% for 2000-2006 and 30.1% for 2007-2013). It has to be noted however that one third of the R&D funds in the current programming was allocated to the research and innovation process in SMEs including voucher schemes, which may also be used for knowledge transfer.

Cooperation: Share of innovative companies cooperating with academia

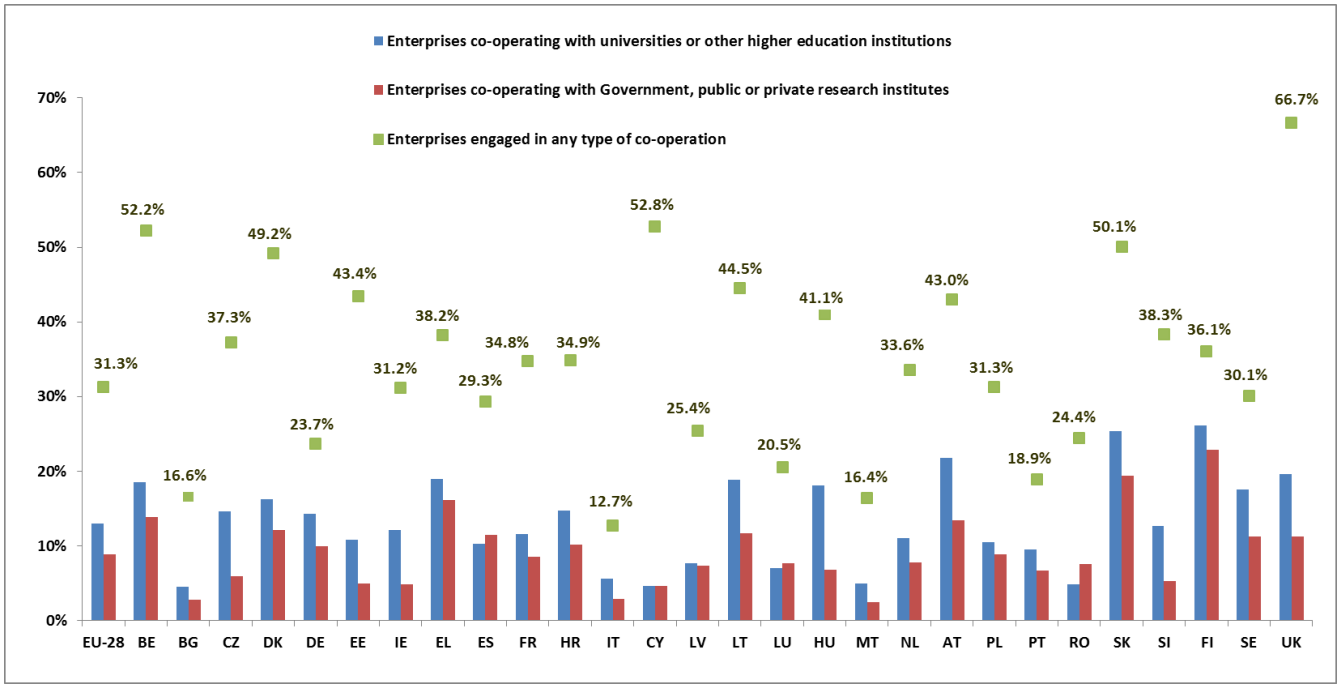

Figure 18 CIS survey 2012 – share of enterprises cooperating with academia.

Figure 18 depicts the level of cooperation activities of innovative companies in the EU-28, according to the CIS 2012. The percentage of "enterprises engaged in any type of co-operation" (green dot) is equal to the EU-28 average (31.3%). The percentage of enterprises involved in cooperation with universities or other HEIs (blue bar) is 10.5%, whereas the share cooperating with government, public or private research institutes (red bar) is 8.9%. Both indicators are close to EU-28 average, which are 13.0% and 8.9% respectively.

Cooperation: Technology Transfer Offices (TTOs), incubators and technological parks

Poland has 71 Technology Transfer Offices, 73 University Business Incubators, 58 Business Incubators, 30 Technology Incubators and 53 Science and Technology Parks[37]. This great number of intermediaries has not resulted in significant amount of results. These facilities are still relatively young (even if the first incubator was established in the 1990s)38, therefore it is difficult to assess their performance.

Cooperation: Share of public-private co-publications

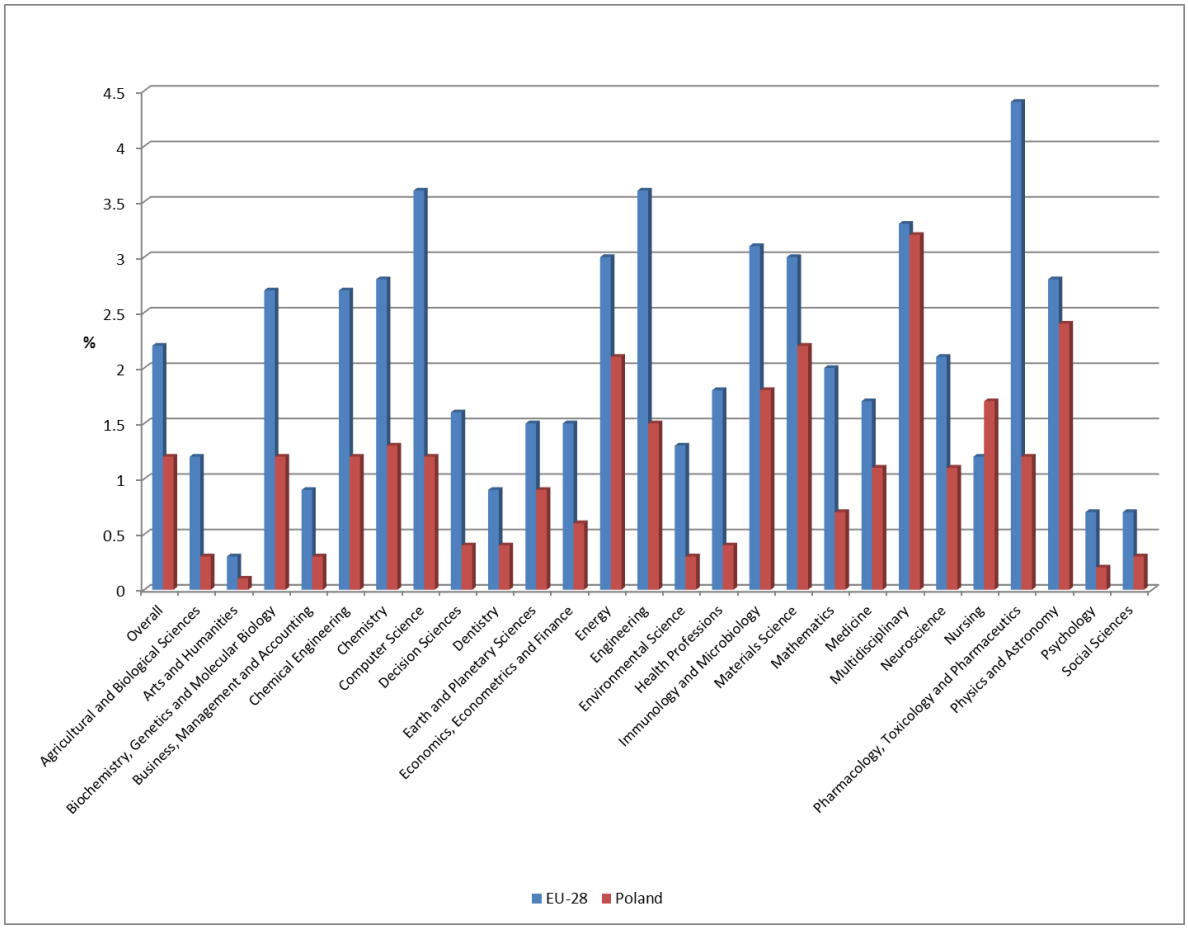

Figure 19 Public-private co-publications by field in Poland, 2003-2013.
Source: Scopus database.

[37] http://www.pi.gov.pl/IOB/chapter_86460.asp,
http://www.pi.gov.pl/IOB/chapter_86467.asp,
http://www.pi.gov.pl/IOB/chapter_86470.asp,
38
http://www.pi.gov.pl/PARPFiles/file/OIB/IOB_Raporty_po_angielsku/BSI_in_Poland_02_TechIncubators.pdf

The Figure 19 shows the 2003-2013 average percentage of academia-industry co-publications by field in Poland compared to the European average. The total share of co-publications, displayed by the red "overall" bar on the left of the chart, is 1.1%, half of the EU-28 average of 2.2%. Excluding multidisciplinary publications, the domains recording the highest share of co-publications are energy, material science and physics and astronomy. Only nursing stands out as a field with higher share of co-publication than the EU average.

With 9.8 co-publications per million population, Poland is far from the EU-28 average of 29.0 and even far from neighbouring countries (17.5 for Czech Republic, 12.8 for Hungary), the gap with the Innovation Leaders (Denmark at 182.1 or Finland at 155.0) is very large. This is probably because Poland has no tradition of inter-sectoral co-authorships, and R&D collaborations are usually restricted to contracted research or work in a consortium jointly benefiting from public funding.

Cooperation: Inter-sectoral mobility

Inter-sectoral mobility of researchers remains limited. 4.19% of all R&D personnel in business enterprises (1,357 out of 32,381 persons) have doctoral degrees, habilitations or professor titles (GUS, 2014b). Out of 10,654 holders of the professor title, 73 work as R&D personnel in business enterprises (0.68%) (GUS, 2014b).

Cooperation: Patenting activity of public research organisations and universities together with licensing income

In 2014 42% of all patent applications in Poland were filed by public research organisations, universities and the Polish Academy of Sciences. Nevertheless, the patents applications from public sector are rarely used. In other words, its main purpose is to increase the rating of a given PRO or HEI.

There is no data on licensing income from these patents, neither on co-patenting activity of academia and business sector.

Cooperation: Companies

There is no available data on the total number of spin-offs in Poland. Moreover, the Polish landscape is confusing due to the existence of companies, established by academics but not affiliated with HEIs or PROs. 27 PHEIs and PROs belong to beneficiaries of NCBiR's funding programme "SPIN-TECH", which supports the establishment of technology transfer companies, and many PHEIs established such companies without the additional support. The Supreme Audit Office in its audit of knowledge transfer activities of higher education institutions from 2012 notes that out of 16 higher education institutions audited, five of them (30% of the sample) have set up 19 spin-offs. It is however extremely difficult to extrapolate the data from such a small sample (12% out of 132[39]) to the whole population of higher education institutions.

5.7.2 Policy measures

The Enterprise Development Programme for the years 2014-2020 foresaw the simplification of IP rules for public research institutes, strengthening science-business links through regional instruments financing private sector secondments of academics.

The science and higher education reform from 2010-2011 was intended to induce synergies between the science and industry sectors in order to stimulate the overall innovativeness of the economy. The amendments of the Act on Higher Education from 2011 introduced rules on academic incubators, TTOs and special purpose vehicles to enable commercialisation of research at universities.

[39] https://www.nauka.gov.pl/g2/oryginal/2013_07/0695136d37bd577c8ab03acc5c59a1f6.pdf

The Act on Principles of Science Financing (2010) introduced the possibility of funding joint initiatives between scientific organizations and business enterprises, especially the formation of research consortia. The Act on Research Institutes (2010) laid out rules for pursuing research collaboration with the industry. The amendments to the Act on Higher Education from 2014 foresee new rules for commercialisation of research in universities with a mix of university ownership and the inventor ownership model. Traditionally, the ownership of academic patents was controlled by the employing institution, but after the legal reform, researchers can become owners of the IPRs to their inventions, if their employers fail to undertake commercialization efforts within 3 months from the initial disclosure of the invention. The amendment was presented as a way of further facilitating the knowledge transfers and overcoming some bureaucratic obstacles related to public finance and public procurement regulations. The re-assignment of IPRs ownership is not automatic and must be preceded by an agreement between the inventor and the institution, which should involve a symbolic payment by the recipient of IPRs, amounting to 10% of the minimum wage (168 PLN, about €40), as well as future royalty payments after the invention is successfully commercialized. These conditions could be further modified by the contracting parties. According to some views, the legislative amendment could have a negative impact on the employing institutions, by depriving them of intellectual assets and restricting potential co-operation with business. The regulation does not affect the PROs, further differentiating the public scientific institutions.

The same amendments to the Act on Higher Education from 2014 obliged PHEIs to define internal procedures for accessing PHEI's research infrastructures by external parties, including business enterprises. This is expected to streamline the commercial use of RI, as many universities hesitated to enter collaborative agreements or allowing private companies access to their laboratories due to the uncertainty regarding the legal admissibility and billing modalities.

Still, the R&I support measures in 2007-2013 focused on 'brick and mortars' solutions (TTOs, incubators) rather than on fostering links between the actors.

The Operational Programme 'Smart Growth' priority axis IV: Increase of scientific and research potential plans amongst other objectives to strengthen cooperation between scientific institutions and enterprises and the public sector. The programme effectiveness will be measured by the share of BERD in the HERD expenses on R&D (baseline: 2.14% in 2012 target for 2023: 4.22%[40]). The regional programme 'Eastern Poland' has also amongst its priorities developing links and synergies between enterprises, research and development centres and higher education sector, in particular promoting investment in product and service development, technology transfer, social innovations, eco-innovations, public services applications, demand stimulation, networking, clusters and open innovations through smart specialisation[41].

The National Innovation Network[42] run by PARP support technological audits (innovation potential) and support SMEs in technology identification/innovation transfers. PARP is also a member of the Enterprise Europe Network.

[40] Other targets are: the number of R&D projects - 200, number of scientific organisations funded in this axis - 150, number of enterprises collaborating with public research institutes - 200, number of personnel involved in funded projects - 3200, number of personnel taking part in development projects - 2100, number of public research organisations receiving funding for research infrastructure – 30.

[41] http://www.mir.gov.pl/fundusze/Fundusze_Europejskie_2014_2020/Documents/POPW_po_RM_8_01_14.pdf

[42] http://ksu.parp.gov.pl/pl/oferta_ksu/innowacyjnosc-w-przedsiebiorstwie

The Polish Patent Office[43] runs workshops and e-learning courses for business (especially SMEs) and business environment organisations on IPR protection. The Ministry of Science and Higher Education has also developed 'A Guide on R&D Commercialisation for Practitioners'[44] which provides information to practitioners on the commercialisation of research results.

The Innovation Portal [45] run by PARP is a source of knowledge on supporting innovativeness and technology transfer. It includes information on, inter alia, availability of new technologies, sources of financing for innovations, institutions and programmes.

The Ministry of Enterprise set up another portal on innovation with a database gathering in one place information on technology reserves of public research institutes and entrepreneurs whom the Minister of Economy granted status of research-development centre.

An important incentive for science-industry cooperation is the regular institutional assessment of scientific organisations, directly influencing the level of institutional funding they can benefit from. The assessment criteria include among others revenues from contracted R&D projects and technology transfer projects. Industry co-operation is also considered when assessing the track of record of individual scientists, who apply for post-doctoral degrees (*habilitations*) or professor titles.

An identified deficiency of the Polish system is the lack of incentives for business enterprises, which would encourage them to sponsor scientific organisations or individual research teams at PHEIs/PROs, e.g. by donating research funds or establishing privately funded chairs. The government entertained in 2012-2013 the possibility of introducing corporate tax benefits in this area, but the plans have never materialized. The Act on Amendments of Some Acts with respect to the Support for Innovativeness, adopted by the Parliament in September 2015, allows business enterprises to classify R&D work contracted to scientific institutions as costs to reduce tax burdens. POIR includes a dedicated support measure no. 2.2, specifically supporting open innovation in the context of optimizing the circulation of knowledge between academia and the private sector, or within the private sector, but details of the instrument are yet to be elaborated.

One of the main objectives of the National Centre for Research and Development, as laid out in its foundation act from 2010, is the support for commercialization and other forms of transfer of scientific research results. The agency has launched multiple knowledge transfer measures namely:

- multiple R&D funding programmes allowing enterprises to cooperate with scientific institutions - most programmes at NCBiR allow the beneficiaries to commission parts of the research to other organisations;
- R&D funding programmes requiring enterprises to form consortia with scientific institutions or incentivizing this co-operation by additional points in the application evaluation process - NCBiR's programmes PBS, INNOTECH, BLUE GAS, GRAF-TECH;
- R&D funding programmes introduced as public-private partnerships, with parts of the programme budget funded by large business enterprises or their associations that co-create the thematic calls for proposals - INNOLOT, INNOMED, CuBR, RID;
- R&D programmes targeting scientific institutions where a business partner in the consortium gives additional points in the proposal evaluation - NCBiR's LIDER and POIR support measure 4.1.4 (applied projects).

[43] http://www.uprp.pl/
[44] http://www.nauka.gov.pl/g2/oryginal/2013_05/e82157b5019e06c7351e0b85cb4d050e.pdf
[45] http://www.pi.gov.pl/

NCBiR introduces additional instruments for the 2014-2020 perspective, including: "*BRIdge Alfa*" (seed capital for academic start-ups) and "*BRIdge VC*" (VC-type of funding for innovative, research-intensive companies), combining the EU funding with the capital provided by private investment funds. New programmes based on the public-private partnership planned for 2016 are INNOCHEM (chemical engineering) and, INNOTEXTILE (technologically advanced textiles).

NCBiR jointly with the consulting company PwC runs a programme *BRIdge Mentor*, offering scientists subsidized, professional consulting services, related to the commercialization of research results. Other consulting services related to development and the implementation of innovative solutions are offered to small and medium-size business enterprises by a network of professional services companies (KSU).

To stimulate the inter-sectoral mobility, NCBiR piloted in 2010-2011 a programme called KadTech, co-funding salaries of scientists, temporarily employed by business enterprises and delegated by PHEIs or PROs to carry out R&D projects. KadTech was not popular among applicants: altogether only two companies were awarded the support, and the programme was discontinued. However, in the financial perspective of 2007-2013, several regionally-funded projects facilitated the temporary employment of scientists by companies in a manner similar to KadTech, with the largest example being TEKLA+ supporting altogether 115 science-industry collaborations.

Other organisations in charge of this policy domain are the Polish Agency for Enterprise Development (PARP) distributing innovation vouchers programme and funding for innovations not related to R&D (e.g. protection of industrial property for SMEs and Research for the market programmes), and the Ministry of Science and Higher Education running *TOP 500 Innovators* programme supporting the development of human resources as well as the *Innovation Brokers* programme. MNiSW also launched a project called "Incubator of innovativeness", subsidizing PHEIs to stimulate the formation of spin-offs and the pursuit of technology licensing transactions.

MNiSW and NCBiR published also several guidebooks, helping understand the legal and economic aspects of research commercialization.

The Industrial Development Agency established in 2015 an IP trading platform to facilitate the match-making activities in the field of knowledge transfer. Additionally, the fundamental science funding agency (NCN) and the National Centre for Research and Development jointly run the programme *TANGO*, which is similar to the ERC Proof of Concept grants.

The Foundation for Polish Science funds internships for Polish scientists in Polish and foreign companies through the SKILLS programme. Thanks to the changes in the law on public aid an intersectoral programme will be run also by the National Science Centre (NCN).

The Act on Amendments of Some Acts with respect to the Support for Innovativeness facilitates the transfer of intangible assets to newly created companies and lifts related taxes in 2016-2017.

Poland has implemented a series of policy measures stemming from a well aligned set of high-level strategies that are covering both the demand and the supply side. Also the funding that has been allocated towards projects reinforcing the links between academia and business and focused on commercialisation has increased significantly in the last seven years. What is more, Poland puts even more stress on the knowledge transfer in the current programming period, using more domestic and EU funds towards the realisation of this goal.

Since the most important KT policies were implemented in the last four years and most of the projects are still running, it is too early to evaluate the impact of the policies put in place. Therefore, we can only see the change from the input indicators side (especially the level of R&D funding for KT). The output indicators (especially those with a long time lag as co-patenting or co-publications) are still not satisfactory.

The major weakness of the KT system is the demand side of the KT value chain linked to low innovativeness of the Polish business sector and especially the SMEs. Therefore, as recognised by the Polish government, in the current programming period the stress will be put on leveraging business R&D with the important amount of the structural funds targeting SMEs, including the innovation vouchers.

Moreover, the links between academia and industry are still weak but the cooperation already increased through various consortia that compete for project funding. The other reasons for the increased activity are the newly established Technology Transfer Offices and a possibility of setting up special purpose vehicles that allow for the commercialisation activity of public higher education institutions.

The strength of Poland lies in a well-aligned KT policy underpinned by long-term strategies and clear goals for the next seven years. Also the research activity of public research institutions is being geared towards the economic priorities through the National and regional Smart Specialisation Strategies. Finally, sectoral programmes (both grants and public-private partnerships) linked to the Smart Specialisation Strategy that target strategic sectors are run already by the NCBiR and are continued in this programming period. Recent changes to the rules of IPR management concerning academic inventions were intended to stimulate the growth of knowledge markets by empowering scientists to assume the ownership of their inventions, but HEIs and PROs tend to exercise their rights to exploit the IPRs by themselves, so the impact of the new regulations on the science-industry collaborations remains ambiguous.

5.8 Regulation and innovation

Poland does not take policy actions, intended to assess the impact of regulation on innovation. All proposed legal acts are accompanied by the formally required impact analyses, which are made publicly available (pl. *ocena skutków regulacji*, *OSR*). In 2006, the Ministry of Economy appointed PARP to analyse impact of new regulations on entrepreneurship and innovativeness (MG, 2006), but this task delegation was not formalized and there is no evidence of PARP having prepared such studies in recent years. Many important regulations do not seem accompanied by sufficient insights into their expected implications, and the contents of the regulatory impact studies relevant for the R&I system tend to be vague, lacking quantitative data, simulations, international benchmarks or other systematic analyses. Examples of such shortcomings include: the failed attempt by the Ministry of Administration and Digitalisation to introduce open access to public resources (2012), which was running the risk of preventing the commercialisation of results of any publicly funded R&D projects; the proposed amendments to the Act on Higher Education (2014), which were initially intended to assign the ownership of academic IPRs to scientists, stripping PHEIs and PROs of this intellectual property and nullifying the previous academic technology transfer efforts; or the Act on Amendments of Some Acts with respect to the Support for Innovativeness (2015), with its first version, submitted by the President in the course of the election campaign, proposing substantial tax exemptions for R&D performing business enterprises, without an adequate analysis of the budgetary implications. Polish legislative procedures include extensive public consultations of draft bills and in all of the above-mentioned cases, stakeholders from the government and other institutions managed to identify possible negative implications of these proposals, but no government body was consistently analysing the impacts on innovations across multiple regulatory proposals.

For innovation-related regulations, no ex post studies were carried out in recent years. In 2013, the Supreme Audit Office (NIK) published results of a comprehensive audit concerning the commercialisation of research results at PHEIs and PROs, criticizing the limited scale of these efforts and procedural challenges (NIK, 2013). Substantial changes in the academic technology transfer system were induced by the science and higher education reform of 2010-2011 with some relevant regulations coming into force in 2012 or 2013, so an ex post evaluation of the reform seemed premature.

Despite the lack of systematic policy actions related to the assessment of the regulatory impact on innovation, the government policies place a high value on innovations, and the wide variety of regulations and support measures introduced in recent years, described in the present report, demonstrate the actual importance of innovativeness for policy actions in Poland.

5.9 Assessment of the framework conditions for business R&I

The Polish R&I policies contributed to substantial increases in private-sector's R&D expenditures and increased interests in innovations in recent years. There is a strong focus on supply-side policies and instruments, offering public co-funding and stimulating private funding for R&I, including VC funds, incubators, business angels, and *NewConnect* stock exchange. It must be noted that VCs and other investors tend to prefer low-risk investments instead of high-tech ventures, due to the wide availability of attractive investment opportunities in Poland, but newly introduced instruments target financial institutions to increase their involvement in markets for innovation. While competitively distributed grants for R&D performers are widely available, accounting and tax regulations do not encourage investments in R&D.

There are multiple supply-side schemes to finance innovation, and in 2007-2013, the number of such schemes seemed excessive, with blurring targets and differentiation problems. PRP identified this as a major challenge, as it encouraged the duplication of corporate efforts, with companies trying to submit applications to many similar funding programmes. The system foreseen for the years of 2014-2020 is more streamlined, and instruments are expected to be well-targeted and easy to differentiate. Recent improvements concern also the reduction of excessive administrative burden in project funding procedures. This problem was identified by World Bank in its evaluation of the Polish R&I system in 2012, and the government responded by highlighting the importance of relevant improvements in PRP, and taking action with reference to specific grant application procedures (e.g. NCBiR managed to simplify its project applications and significantly reduced the application evaluation period to issue funding decisions within 60 days from the application submission date).

Demand-side policies seem under-valued by the government, with limited use of innovative public procurement and technological standards (with the exception of ICT, defence, energy efficiency and health technologies). Policy framework did not consider the possibility of co-evolution of supply and demand-side instruments, so the possible synergies have not been explored or strengthened.

6. Conclusions

6.1 Meeting structural challenges

The policy mix in Poland related to the five identified structural challenges is discussed in Table 9 , which lists relevant policy actions, assesses their appropriateness, efficiency and effectiveness, and provides links to relevant evidence (based on evaluations or empirical analyses).

Table 9 Policy measures addressing structural challenges in Poland.

Structural challenge	Policy actions addressing the challenge	Assessment in terms of appropriateness, efficiency and effectiveness	Evidence on the impact and outcomes of policy actions
(1) Low intensity of private R&I	• Observed changes in policy focus from innovation absorption to R&I support, demonstrated in top-level policy documents SIEG, PRP and POIR in 2013-2015. • Changes in the public discourse by policy makers and journalists - since 2013, innovations became a very important topic for national policies. • Multiple R&D funding schemes by NCBiR, increasing the share of private investments (including programmes developed as public-private partnerships, with disproportionally high private co-funding). • POIR and RPOs with substantial budgets for applied R&D by business enterprises for 2014-2020, expected to induce private co-funding. • Government incentive scheme amended in 2014 to attract R&D-based FDIs. • Public support for activities of VC funds (including KFK, NCBiR's BRIdge programmes and ARP).	Funding programmes by NCBiR induced substantial new investments in R&D by business enterprises. Large increases in Poland's BERD were registered in 2012 and 2013 (even in spite of limited reporting of R&D expenditures). POIR is likely to successfully promote the increased innovativeness due to better-targeted interventions, and growing importance of R&D as evidenced by public discourse. A major shortcoming is the lack of R&D tax exemptions, which were promised in PRP and initially included in the draft Act on Amendments of Some Acts with respect to the Support for Innovativeness, but these elements of the Act were eliminated in the course of parliamentary work. Streamlining the R&D reporting in corporate financial and tax accounting systems, resulting from the Act, is likely to raise awareness of corporate management and financial specialists of R&D cost categories, and could be considered a good first step towards a potential future transformation of	Evaluation of the R&I system, carried out by the World Bank, including private R&D investment (Kapil et al., 2012). Analysis of R&D project selection criteria (CRSG, 2013). Survey of business enterprises, declaring willingness to increase R&D expenditures (KPMG, 2013). Analysis of R&D propensity of innovative companies supplying environmental technologies (Klincewicz et al., 2013). Analysis of private investments in R&D projects co-funded by NCBiR (PwC, 2014). Regularly published data on private co-funding of R&D projects, supported by NCBiR (NCBiR, 2015b). Evaluation of R&D support measures in 2007-2013 (OPI-Millward Brown, 2014). Evaluation of the impact of support measures, 2007-2013, on the innovativeness of business enterprises (WYG PSDB, 2014). Impact assessment of the EU Structural Funding on large enterprises (PAG

Structural challenge	Policy actions addressing the challenge	Assessment in terms of appropriateness, efficiency and effectiveness	Evidence on the impact and outcomes of policy actions
	• Act on Amendments of Some Acts with respect to the Support for Innovativeness (2015), making R&D expenditures partly deductible and introducing relevant book-keeping requirements. • NCBiR requiring beneficiaries to declare R&D expenditures and reminding of the legal reporting obligations.	relevant tax regulations. It must be noted that more Polish companies invest substantial budgets in R&D more actively than the EU Industrial R&D Investment Scoreboard indicated (comp. Annex 3).	Uniconsult, 2014). Ex-ante evaluation of POIR, including the planned support for R&I projects by business enterprises (PSDB, 2014).
(2) Cooperation between science and industry	• Increased number of R&D funding programmes, promoting collaborative research involving science and industry – both among existing and planned support measures, available through NCBiR. • Use of "innovation voucher" to stimulate contracted R&D, performed by scientists for enterprises. • Support measures in POIR dedicated for science-industry consortia. • Institutional assessment of PROs and PHEIs (and thus availability of institutional R&D funding) depends among others on documented technology transfers to industry and co-operative projects. • Legal framework, supporting the establishment of special purpose companies by PHEIs and scientific and industrial centres by PROs. • Funding schemes stimulating science-industry collaboration: SPIN-TECH, Innovation brokers, Top 500 Innovators, Creator of	The structural challenge is widely recognized by the Polish government, and adequately addressed by a number of well-targeted measures. Due to the dynamic changes of institutional frameworks in 2010-2015, extensive evaluations would be premature, but multiple positive tendencies can be identified. Business companies participate jointly with scientists in multiple funding programmes by NCBiR, PHEIs and PROs have first successes in commercializing academic inventions, and the worlds of science and industry have slowly started discovering each other in Poland. There is visible change in science-industry collaborations, and positive opinions of corporate management about the changes (comp. KPMG, 2013). Continuation of this approach with the funding from POIR in 204-2020 can be expected to further intensify the co-operation and motivate scientists to proactively embrace the technology market. Novel approaches such as BRIdge attempt to follow the best practices tested in Israel, with public-	Evaluation of the R&I system, carried out by the World Bank, taking into account linkages between business enterprises and scientific organisations (Kapil et al., 2012). Negative conclusions of science sector audit, based on data collected directly after the science reform (NIK, 2013). Survey of business enterprises, indicating the willingness to co-operate with scientific organisations (KPMG, 2013). Analysis of science-industry collaboration involving the development of environmental technologies (Klincewicz et al., 2013). Analysis of private involvement in publicly co-funded R&D projects (PwC, 2014). Evaluation of R&D support measures in 2007-2013 (OPI-Millward Brown, 2014). Ex-ante evaluation of POIR, including the planned support for R&I projects by business enterprises (PSDB, 2014).

Structural challenge	Policy actions addressing the challenge	Assessment in terms of appropriateness, efficiency and effectiveness	Evidence on the impact and outcomes of policy actions
	innovativeness, BRIdge, TANGO. • Amendments to the Act on Higher Education from 2014, facilitating the assignment of IPRs to scientists in order to promote their collaboration with industry.	private partnerships stimulating R&D projects by industry working with academics and VC specialists.	
(3) Low quality of public research base	• Increased importance of grants versus institutional funding. • Competitively distributed project funding and multiple R&I support measures available to researchers from PHEIs and PROs. • Increased involvement of foreign experts in peer-review processes at NCN and NCBiR and criteria referring to scientific excellence. • Redesign of the "National Programme for the Development of Humanities" (2015) to strengthen interdisciplinary research and internationalization of humanities and social sciences. • Improvements and internationalisation of doctoral studies, enforced by government regulations (2013) and supported by the EU Structural Funds (POKL, 2007-2013; POWER, 2014-2020). • Nation-wide institutional assessment, determining the level of institutional funding of scientific organisations, conducted for the first time in 2013, with rules amended in 2015. Since 2015, institutional funding depends only on the outcome of the current	Younger generations of researchers reorient their scientific activities towards international publications and the spirit of academic competitiveness, but the policy focus on project funding is heavily contested by many representatives of scientific organisations, in particular by researchers in humanities. Rules for institutional assessment of scientific organisations are based on semi-automated, quantitative analysis of outputs, disregarding the actual scientific impact or excellence. Due to the assessments, researchers and employing institutions cope with increased administrative workloads, and the system is perceived as overly bureaucratic. Moreover, important elements of the institutional assessment are based on the effectiveness of attracting grants, i.e. the level of available institutional funding becomes heavily dependent on previous successes in project funding, thus undermining this dichotomy and restricting the stability of financing for many scientific endeavours. Substantial investments in research infrastructures from 2007-2013 did not sufficiently promote inter-organisational collaboration and the potential of many implemented RIs is not sufficiently exploited.	No comprehensive evaluations of Polish science or scientific institutions were carried out in recent years. NCN and NCBiR generated statistical summaries of data on R&D projects funded by the agencies (NCN, 2015; NCBiR, 2015b).

Structural challenge	Policy actions addressing the challenge	Assessment in terms of appropriateness, efficiency and effectiveness	Evidence on the impact and outcomes of policy actions
	assessment, and results of previous assessments are no longer taken into account. • Public investments in large research infrastructures, including the national roadmap PMDIB, and the establishment of modern research infrastructure in PHEIs and PROs in 2007-2013. • Financial support for the internationalisation of science, including Polish participation in international research programmes. • Active promotion of Polish involvement in Horizon 2020, including "Pact for Horizon 2020" signed by MNiSW and leading scientific organisations. • New programme "POLONEZ" intended to attract leading foreign researchers to Poland. • Support measures in POIR targeting international collaboration with leading international institutions and creation of virtual research institutes, promoting synergies with Horizon 2020 funding.	New support measures, included in POIR and introduced by NCBiR in 2014-2015, seem to adequately address the identified challenges related to the quality of science, but their uptake will take several years.	
(4) Attracting R&D focused FDI and creating knowledge-spillovers from FDIs	• Multiple support instruments, stimulating international co-operation in R&D (MNiSW, PARP). • PAIZ attracting foreign investors, with focus on R&D-related investments, and government amended in 2014 rules of financially supporting new FDIs to encourage R&D-oriented ventures.	FDIs gradually shift focus from production and service facilities to R&D, and Poland was perceived as one of top future R&D destinations by international companies according to the 2013 EU Survey on Industrial R&D Investment Trends. R&D spending of foreign-owned companies in Poland increased substantially between 2009 and 2013. Nevertheless, the share of R&D-focused	Evaluation of Poland's R&I system, involving its internationalisation, carried out by World Bank (Kapil et al., 2012).

Structural challenge	Policy actions addressing the challenge	Assessment in terms of appropriateness, efficiency and effectiveness	Evidence on the impact and outcomes of policy actions
	• Foreign investors, establishing subsidiaries in Poland, can benefit from all R&I support measures, including instruments in POIR. • NCBiR, KFK and PARP co-operate with foreign VC and investment funds, jointly launching investments in innovative SMEs in Poland.	FDIs is still relatively low, and most investors regard Poland primarily as the supplier of low cost labour for manufacturing and service operations.	
(5) Priority setting in the R&I governance system	• National Smart Specialisation (KIS) as a list of national R&I priorities adopted in 2014 (resulting from two large-scale foresights for science and industry). • Smart specialization strategies of 16 Polish regions prepared in 2014-2015. • POIR and RPOs have specific shares of budgets allocated to fund only projects consistent with KIS or regional specialisations (formal requirement for project selection). • NCBiR's sectoral programmes targeting specific prioritized areas, with policy actions defined in a bottom-up manner, consistent with the entrepreneurial discovery process.	In 2013-2014, the R&I policy framework was modified to include stronger prioritization through KIS and regional smart specialisation strategies, and significant part of R&I funding in the 2014-2020 perspective will focus on technological areas identified as key for the Polish economy. Evaluation of the efficiency and effectiveness is premature in 2015, as the relevant support measures have only recently been introduced, with the launch of POIR and RPOs. The prioritization offers strong signals to the business community, which started planning future R&D projects by taking into account the preferred investment directions. However, some specialisation areas are very general and all-encompassing, thus undermining the very concept of concentration of resources. Several sectoral programmes of NCBiR, which have already been implemented, deliver benefits by targeting specific types of R&D projects, needed for the respective sectors, and stimulate increases in private co-funding.	Evaluation of KIS and regional smart specialisation strategies, prepared by World Bank (unpublished, 2014). Ex-ante evaluation of POIR, including the planned support for R&I projects by business enterprises (PSDB, 2014).

Source: own.

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Abbreviations

ACTA	Anti-Counterfeiting Trade Agreement
ARP	Industrial Development Agency (Agencja Rozwoju Przemysłu)
BERD	Business Expenditures for Research and Development
BES	Business Enterprise Sector
BGK	Bank Gospodarstwa Krajowego
CIS	Community Innovation Survey
CSR	Country-specific Recommendations
EC	European Commission
ERA	European Research Area
EPO	European Patent Office
ERA-NET	European Research Area Network
ESA	European Space Agency
EU	European Union
EU-28	European Union including 28 Member States
FDI	Foreign Direct Investment
FNP	Foundation for Polish Science (Fundacja na rzecz Nauki Polskiej)
FP7	7th Framework Programme
FTE	Full-time equivalent
GBAORD	Government Budget Appropriations or Outlays on R&D
GDP	Gross Domestic Product
GERD	Gross Domestic Expenditure on R&D
GOVERD	Government Intramural Expenditure on R&D
GPP	Green Public Procurement
GVA	Gross Value Added
HEI	Higher Education Institution
HES	Higher Education Sector

HERD	Higher Education Expenditure on R&D
HRST	Human Resources for Science and Technology
H2020	Horizon 2020
ICT	Information & Communication Technologies
ISCED	International Standard Classification of Education
IU	Innovation Union
KEJN	Committee for Evaluation of Scientific Research Institutions (Komitet Ewaluacji Jednostek Naukowych)
KFK	National Capital Fund (Krajowy Fundusz Kapitałowy)
KIS	National Smart Specialisations (Krajowe Inteligentne Specjalizacje)
KNOW	National Scientific Leading Centre (Krajowy Naukowy Ośrodek Wiodący)
KPB	National Research Programme (Krajowy Program Badań)
KPK	National Contact Point for Research Programmes of the European Union (Krajowy Punkt Kontaktowy Programów Badawczych UE)
KPN	Committee for Science Policy (Komitet Polityki Naukowej)
KRASP	Conference of Rectors of Academic Schools in Poland (Konferencja Rektorów Akademickich Szkół Polskich)
KSU	National Service System for Small and Medium-Sized Enterprises (Krajowy System Usług)
MF	Ministry of Finance (Ministerstwo Finansów)
MG	Ministry of Economy (Ministerstwo Gospodarki)
MIR	Ministry of Infrastructure and Development (Ministerstwo Infrastruktury i Rozwoju)
MNiSW	Ministry of Science and Higher Education (Ministerstwo Nauki i Szkolnictwa Wyższego)
MR	Ministry of Economic Development (Ministerstwo Rozwoju)
NCBiR	National R&D Centre (Narodowe Centrum Badań i Rozwoju)
NCN	National Science Centre (Narodowe Centrum Nauki)
NFOŚiGW	National Fund for Environmental Protection and Water Management (Narodowy Fundusz Ochrony Środowiska i Gospodarki Wodnej)
NIK	Supreme Audit Office (Najwyższa Izba Kontroli)

OPI	Information Processing Centre (Ośrodek Przetwarzania Informacji)
PAN	Polish Academy of Sciences (Polska Akademia Nauk)
PAIZ	Polish Information and Foreign Investment Agency (Polska Agencja Informacji i Inwestycji Zagranicznych)
PARP	Polish Agency for Enterprise Development (Polska Agencja Rozwoju Przedsiębiorczości)
PCP	Pre-commercial Procurement
PCT	Patent Co-operation Treaty
PHEI	Public Higher Education Institution
PIR	Polish Development Investments (Polskie Inwestycje Rozwojowe)
PiS	Right and Justice Party (Prawo i Sprawiedliwość)
PLN	Polish zloty
PMDIB	Polish Roadmap of Research Infrastructure (Polska Mapa Drogowa Infrastruktury Badawczej)
PNP	Private non-profit sector
PO	Civic Platform (Platforma Obywatelska)
POIG	Operational Programme Innovative Economy (Program Operacyjny Innowacyjna Gospodarka)
POIR	Operational Programme Smart Growth (Program Operacyjny Inteligentny Rozwój)
PRO	Public Research Organization
PRP	Enterprise Development Programme (Program Rozwoju Przedsiębiorstw)
PSL	Polish People's Party (Polskie Stronnictwo Ludowe)
R&D	Research and development
RI	Research Infrastructure
R&I	Research and innovation
RIS3	Research and Innovation Strategies on Smart Specialisation
RPO	Regional Operational Programme (Regionalny Program Operacyjny)
SF	EU Structural Funds
S3	Smart Specialisation Strategy

S&T	Science and technology
SIEG	Strategy for the Innovation and Efficiency of the Economy (Strategia Innowacyjności i Efektywności Gospodarki)
SME	Small and Medium-sized Enterprise
TTO	Technology Transfer Office
VC	Venture Capital

List of Figures

List of Tables

Annex 1 – List of the main research performers

Main private research performers				
No.	**Company name**	**City**	**Sector**	**R&D expenditures in 2011 (€m)**
1.	Fiat Auto Poland S.A.	Bielsko-Biała	automotive	70.870
2.	Grupa Bumar	Warszawa	defense	32.482
3.	Asseco Poland S.A.	Rzeszów	ICT	27.681
4.	Comarch S.A.	Kraków	ICT	16.256
5.	Zakłady Farmaceutyczne Polpharma S.A.	Starogard Gdański	pharmaceuticals	14.966
6.	Telekomunikacja Polska S.A. (Orange Polska S.A.)	Warszawa	telecommunications	13.227
7.	Valeo Autosystemy Sp. z o.o.	Skawina	automotive	12.942
8.	ABB Sp. z o.o.	Warszawa	industrial machinery	11.449
9.	Automotive Lighting Polska Sp. z o.o.	Sosnowiec	automotive	9.516
10.	Mondi Świecie S.A.	Świecie	paper	9.466
11.	KGHM CUPRUM Sp. z o.o.	Wrocław	copper mining	9.335
12.	Solaris Bus & Coach S.A.	Bolechowo	automotive	8.823
13.	Adamed Sp. z o.o.	Czosnów	pharmaceuticals	8.493
14.	Pojazdy Szynowe PESA Bydgoszcz S.A.	Bydgoszcz	automotive	7.999
15.	Obrum Sp. z o.o.	Gliwice	defense	6.213
16.	Netia S.A.	Warszawa	telecommunications	6.144
17.	Autoliv Poland Sp. z o.o.	Oława	defense	6.071
18.	Bank Ochrony Środowiska S.A.	Warszawa	financial services	5.903
19.	City Interactive S.A. (CI Games S.A.)	Warszawa	ICT	5.774

20.	Krynicki Recykling S.A.	Olsztyn	environmental technologies	5.496

Source: Baczko et al. (2013: 28, 38). Data on R&D expenditures converted using the exchange rate of 1€ = 4.1198 PLN (2011).

Main public research performers			
No.	**Organisation name (in Polish)**	**English name**	**Publications in 2013-2014**
1.	Uniwersytet Warszawski	University of Warsaw	4,150
2.	Uniwersytet Jagielloński w Krakowie	Jagiellonian University in Krakow	3,906
3.	Akademia Górniczo-Hutnicza im. Stanisława Staszica w Krakowie	AGH University of Technology in Krakow	3,819
4.	Politechnika Warszawska	Warsaw University of Technology	3,415
5.	Politechnika Wroclawska	Wroclaw University of Technology	2,763
6.	Politechnika Śląska w Gliwicach	Silesian University of Technology in Gliwice	2,302
7.	Uniwersytet im. Adama Mickiewicza w Poznaniu	Adam Mickiewicz University in Poznan	2,209
8.	Warszawski Uniwersytet Medyczny	Medical University of Warsaw	1,878
9.	Uniwersytet Wrocławski	University of Wroclaw	1,873
10.	Uniwersytet Medyczny w Łodzi	Medical University of Lodz	1,808
11.	Politechnika Łódzka	Lodz University of Technology	1,649
12.	Uniwersytet Medyczny w Poznaniu	Poznan University of Medical Sciences	1,591
13.	Uniwersytet Śląski w Katowicach	Silesian University in Katowice	1,563
14.	Politechnika Gdańska	Gdansk University of Technology	1,443
15.	Uniwersytet Medyczny im. Piastów Śląskich we Wroclawiu	Medical University of Wroclaw	1,422
16.	Politechnika Poznańska	Poznan University of Technology	1,418

17.	Uniwersytet Łódzki	University of Lodz	1,401
18.	Śląski Uniwersytet Medyczny w Katowicach	Silesian University of Medicine in Katowice	1,392
19.	Uniwersytet Warmińsko-Mazurski w Olsztynie	University of Warmia and Mazury in Olsztyn	1,319
20.	Uniwersytet Mikołaja Kopernika w Toruniu	Nicolaus Copernicus University in Torun	1,272
-	73 instytuty naukowe Polskiej Akademii Nauk	73 scientific institutes of the Polish Academy of Sciences	10,670

Source: own analysis of Elsevier Scopus database, publication data for 2013-2014 compiled on 19.9.2015, based on all 75,123 publications with Polish affiliations. No single institute of the Polish Academy of Sciences was included among the top 20 performers - the Academy is a conglomerate of diverse research institutions in different parts of Poland, and thus could not be directly listed in the ranking.

Annex 2 – List of the main funding programmes

Name of the funding programme	Timeline	Budget (m€)[46]	Funding agency	Target group
Fundamental research				
OPUS	permanent	96.6	NCN	large projects, usually for experienced researchers
MAESTRO	permanent	21.9	NCN	the most experienced researchers
SONATA	permanent	24.2	NCN	recent PhDs
PRELUDIUM	permanent	16.8	NCN	doctoral candidates
HARMONIA	permanent	15.7	NCN	international collaborative projects
IUVENTUS PLUS	permanent	5.4	MNiSW	young researchers
SONATA BIS	permanent	9.7	NCN	researchers 2-12 years after PhD
National Programme for Development of Humanities	permanent	5.5 (19.1 in 2015)	MNiSW	large projects in humanities and social sciences
IDEAS PLUS	permanent	1.6	MNiSW	finalists of ERC programme IDEAS, who were not granted ERC support
FUGA	permanent	3.8	NCN	recent PhDs
ETIUDA	permanent	2.1	NCN	doctoral candidates
SYMFONIA	permanent	3.9	NCN	the most experienced researchers

[46] Unless otherwise specified, the table presents the executed budgets of the R&D programmes in 2014, based on the budgetary report of the Ministry of Science and Higher Education (MNiSW, 2015a). Expenditures were converted from PLN to Euro using the rate 1€ = 4.1852 PLN (annual exchange rate for 2014, published by NBP).

POLONEZ	2015-2020	9.55 (2016)	NCN	experienced foreign scientists planning to carry out R&D projects in Poland
Virtual Research Institutes (*Wirtualne instytuty badawcze*, POIR 4.1.3)	2015-2020	70 (2015-2020)	FNP	R&D projects complementing the Horizon 2020 "Twinning" initiative
International research agendas (*Międzynarodowe agendy badawcze*, POIR 4.3)	2015-2020	127 (2015-2020)	NCBiR	funding for the leading internationally oriented R&D agendas to complement the Horizon 2020 "Teaming for excellence" initiative
Improving the R&D personnel potential (*Zwiększanie potencjału kadrowego sektora B+R*, POIR 4.4)	2015-2020	160 (2015-2020)	FNP	several dedicated support measures promoting research excellence, with ERC-type grants to establish new research teams, support for Polish citizens relocating back to Poland after an extended period of research abroad, and internships of scientists in business enterprises, based on proven frameworks established by FNP in previous years
Applied research, development and innovation				
POIG 1	2007-2015	313.9	NCBiR	applied R&D, based on EU Structural Funds (multiple measures targeting scientific and business organisations, including POIG 1.4, DEMONSTRATOR+, INNOLOT)
POIG 2	2007-2015	274.1	NCBiR	support for research infrastructure, based on the EU Structural Funds
Defence	permanent	80.1	NCBiR	defence R&D
PBS	permanent	78.6	NCBiR	generic applied R&D programme, open to science-industry consortia
INNOTECH	permanent	30.1	NCBiR	development of innovative technologies

Advanced energy generation technologies	2010-2015	10.9	NCBiR	R&D related to energy
STRATEGMED	from 2014	3.2	NCBiR	development of technologies addressing lifestyle diseases
GEKON	2012-2018	4.9	NCBiR-NFOŚiGW	development of environmental technologies
Polish-Norwegian Research Cooperation	no new calls	68 (2012-2017)	NCBiR	applied R&D targeting identified social challenges
LIDER	permanent	8.4	NCBiR	applied R&D for young researchers
BLUE GAS	no new calls	5.5	NCBiR-ARP	development of shale gas-related technologies by science-industry consortia
GRAF-TECH	no new calls	4.9	NCBiR	development of graphene-related technologies by science-industry consortia
Safe nuclear energy	no new calls	2.9	NCBiR	R&D related to nuclear energy
Creator of innovativeness	no new calls	0.5	NCBiR	funding project of technology transfer centres at PHEIs
Mining safety	no new calls	0.5	NCBiR	R&D related to the improvement of mining safety
SPIN-TECH	no new calls	0.9	NCBiR	funding newly established technology transfer companies of PHEIs and PROs
"SIMS" ("Science Infrastructure Management Support")	2013-2015	NA	NCBiR	training and consulting services for PHEIs and PROs, which benefited from POIG (2007-2013) and established large research infrastructures

GO_GLOBAL.PL	permanent	1.1	NCBiR	international expansion of technology companies
BRIdge Mentor	2013-2015	1.6	NCBiR	commercialization of scientific research
BRIdge Alfa (POIR 1.3.1)	2015-2020	213 (2015-2020)	NCBiR	seed funding for start-ups based on academic inventions
BRIdge VC (POIR 1.3.2)	2015-2020	225 (2015-2020)	NCBiR	co-funding VC involvement in innovative SMEs
"Open innovations" (*Otwarte innowacje*, POIR 2.2)	2015-2020	125 (2015-2020)	ARP	establishment of a database of available technologies and experts at PHEIs and PROs, match-making with companies and financial support for technology transfers
PATENT PLUS	permanent	0.5	NCBiR	IPR protection at PHEIs, PROs and business enterprises
Social innovations (*Innowacje społeczne*)	permanent	1.1	NCBiR	development of solutions addressing identified social problems
TANGO	from 2015	11.5 (2015)	NCBiR-NCN	developing a proof-of-concept for technologies resulting from fundamental research projects, previously funded by NCN
BIOSTRATEG	2015-2020	119.4 (2015-2020)	NCBiR	development of technologies related to agriculture, food production, water management, climate change, biodiversity protection and forestry
TECHMATSTRATEG	2015-2020	119.4 (2015-2020)	NCBiR	development of technologies based on advanced materials

CuBR	2014-2019	47.8	NCBiR	applied R&D related to non-ferrous metals, co-funded by the copper mining company KGHM
RID	2015-2019	11.9	NCBiR	development of transportation technologies, co-funded by the road management company GDDKiA
Industrial research and development by business enterprises ("Fast track", *Szybka ścieżka*, POIR 1.1.1)	2015-2020	1,880 (2015-2020)	NCBiR	main support measure for R&D projects by business enterprises, based on the EU Structural Funds
DEMONSTRATOR+ (POIR 1.1.2)	2015-2020	657 (2015-2020)	NCBiR	technology development projects for business enterprises, focused on developing technology demonstrators or pilot installations
Sectoral programmes (*Programy sektorowe,* POIR 1.2)	2015-2020	875 (2015-2020)	NCBiR	support for research agendas, proposed by representatives of industrial sectors and negotiated with NCBiR; already launched programmes: INNOMED (medical technologies), INNOLOT (aviation); accepted for funding negotiations: INNOCHEM (chemical engineering), INNOTEXTILE (technologically advanced textiles), InnoSBZ (unmanned aerial vehicles); 10 other proposals to be improved and negotiated
Large innovation voucher (*Duży bon na innowacje*)	permanent	0.9 (2015)	PARP	vouchers for SMEs covering the costs of R&D services by scientific organisations

Applied projects (*Projekty aplikacyjne*, POIR 4.1.4)	2015-2020	143 (2015-2020)	NCBiR	applied R&D projects carried out by consortia existing of scientific and business organisations
Innovation voucher (*Bon na innowacje*, POIR 2.3.2)	2015-2020	80.6 (2015-2020)	PARP	vouchers for SMEs covering the costs of R&D services by scientific organisations
Internationalisation of key clusters (*Umiędzynarodowienie Krajowych Klastrów Kluczowych*, POIR 2.3.3.)	2015-2020	33 (2015-2020)	PARP	support for international expansion of innovative clusters, selected in a nation-wide competition
Polish technological bridges (*Polskie mosty technologiczne*, POIR 3.3.1)	2015-2020	42.3 (2015-2020)	MG	acceleration programs for selected high-tech companies, supporting their expansion in international locations, including Silicon Valley
IPR protection (*Ochrona własności przemysłowej*, POIR 2.3.4)	2015-2020	47.6 (2015-2020)	PARP	IPR support for SMEs
Research for the market (*Badania na rynek*, POIR 3.2.1)	2015-2020	1,048 (2015-2020)	PARP	support for R&I projects, involving implementation of innovations developed or licensed by business enterprises, contributing to the launch of new products or services and compliant with national smart specializations
Support for investments in R&D infrastructure in business enterprises (*Wsparcie inwestycji w infrastructure B+R przedsiębiorstw*, POIR 2.1)	2015-2020	584 (2015-2020)	MG	financing research infrastructures of business enterprises, linked to identified R&D agendas
Development of modern research infrastructures for the science sector (*Rozwój nowoczesnej infrastruktury badawczej sektora nauki*, POIR 4.2)	2015-2020	452.9 (2015-2020)	OPI	financing large research infrastructures included in the national roadmap PMDIB, with focus on RI suitable for applied R&D and science-industry co-operation

Support for receiving grants (*Wsparcie na uzyskanie grantu*)	permanent	0.7 (2015)	PARP	co-funding the preparation of applications to H2020, COSME and other international programmes by SMEs
E-Pionier – support for talented programmes in order to address identified social or economic challenges (*Wsparcie uzdolnionych programistów na rzecz rozwiązywania zidentyfikowanych problemów społecznych lub gospodarczych*, POPC 3.3)	2015-2020	25 (2015-2020)	NCBiR	funding software development addressing specific, identified societal or economic problems

Annex 3 – Evaluations, consultations, foresight exercises

Project	Published report
Ex-post evaluations of R&I support in the 2007-2013 perspective, based on the EU Structural Funds	
Evaluation of R&D support in 2007-2013	OPI-Millward Brown (2014) Ewaluacja instrumentów wsparcia B+R w ramach perspektywy finansowej 2007-2013. Warszawa, December 2014. http://www.ewaluacja.gov.pl/Wyniki/Documents/2_108.pdf
Evaluation of the impact of POIG on the innovativeness of business enterprises	WYG PSDB (2014a) Ocena wpływu Programu Operacyjnego Innowacyjna Gospodarka na zwiększenie innowacyjności przedsiębiorstw. Warszawa. http://www.ewaluacja.gov.pl/Wyniki/Documents/2_107.pdf
Evaluation of the effects of granting large enterprises support based on the EU Structural Funds	PAG Uniconsult (2014) Ocena efektów wsparcia dużych przedsiębiorstw w ramach realizacji polityki spójności w Polsce. Ministerstwo Infrastruktury i Rozwoju, Warszawa, marzec 2014. https://www.ewaluacja.gov.pl/Wyniki/Documents/7_031.pdf
Evaluations of selected aspects of the R&I system	
Analysis of the private co-funding for R&D projects, offered by NCBiR	PwC (2014) Analiza wysokości wkładu własnego przedsiębiorców i udzielonej pomocy publicznej. Weryfikacja zapisów dot. wysokości wkładu własnego przedsiębiorców projektów badawczo-rozwojowych współfinansowanych przez NCBR. http://www.ncbir.pl/gfx/ncbir/userfiles/_public/aktualnosci/pwc_ekg_maj.pdf
Analysis of the situation of SMEs in Poland	PARP (2014b) Raport o stanie sektora małych i średnich przedsiębiorstw w Polsce w latach 2012–2013. PARP, Warszawa. http://badania.parp.gov.pl/files/74/75/76/21788.pdf
Collection of empirical studies concerning innovations in the business sector	Lichota-Zadura, Paulina (2015) Innowacyjna przedsiębiorczość w Polsce. Odkryty i ukryty potencjał polskiej innowacyjności. PARP, Warszawa. http://badania.parp.gov.pl/files/74/75/76/479/22512.pdf

Study demonstrating the importance of industrial design for the innovativeness of the business sector and recommending possible support measures	Realizacja Sp. z o.o. (2014) Diagnoza stanu design. Ewaluacja zapotrzebowania na wsparcie w zakresie wzornictwa przemysłowego (designu). http://www.ewaluacja.gov.pl/Wyniki/Documents/2_116.pdf
Comprehensive overview of the Polish economy and innovation system, with proposed development pathways till 2025	McKinsey (2015) Poland 2025: Europe's new growth engine. http://www.mckinsey.com/locations/warsaw/publications/Poland%202025_full_report.pdf
Analysis of investments in research infrastructures at PHEIs and PROs	RGNiSW [Rady Głównej Nauki i Szkolnictwa Wyższego] (2015) Inwestycje w infrastrukturę badawczą w polskich uczelniach, instytutach badawczych i instytutach PAN. http://www.rgnisw.nauka.gov.pl/g2/oryginal/2015_02/33dea3c68ccb438ea518f7a0c5acf5d0.pdf
Evaluation of the system of doctoral studies and the mobility of young scientists	RGNiSW [Rady Głównej Nauki i Szkolnictwa Wyższego] (2015) Studia doktoranckie i mobilność młodych naukowców. http://www.rgnisw.nauka.gov.pl/g2/oryginal/2015_05/b1d7b57bd78ae523c9ed9bd36b06a793.pdf
Evaluation of public research institutes	NIK (2015) Efekty działalności instytutów badawczych. Informacja o wynikach kontroli. https://www.nik.gov.pl/plik/id,9522,vp,11765.pdf
Nation-wide survey of start-up companies	Agnieszka Skala, Eliza Kruczkowska, Magdalena A. Olczak (2015) Polskie Startupy. Raport 2015. http://startuppoland.org/wp-content/uploads/2015/10/Startup-Poland_raport_2015.pdf
Study of patent holders, analyzing their propensity to patent and barriers to patenting and effective commercialization of innovations, commissioned by the Polish Patent Office	NA
Evaluations of specific funding programmes	
Evaluation of the support measure "DEMONSTRATOR+", offered by NCBiR	Taylor Economics (2014) Badanie ewaluacyjne Projektu Systemowego NCBR w ramach Działania 1.5 PO IG pn. Wsparcie badań naukowych i prac rozwojowych w skali demonstracyjnej Demonstrator+ w obszarze INFO, BIO oraz w obszarze TECH. Warszawa, November 2014. http://www.ewaluacja.gov.pl/Wyniki/Documents/2_109.pdf

Methodological study, proposing ways of assessing the effectiveness of projects supported by NCBiR through „DEMONSTRATOR+”	EGO (2015) Metodologia oceny efektywności projektów systemowych DEMONSTRATOR+. NCBiR, Warszawa. http://www.ncbir.pl/gfx/ncbir/pl/defaultopisy/1396/1/1/ewaluacja_dot._opracowania_metodologii_pomiaru_efektywnosci_demonstrator_.pdf
„Barometer of innovativeness” – an annual panel survey of trends among business enterprises benefiting from POIG funding	PARP (2014a) Barometr innowacyjności. Ewaluacja on-going Działań 1.4-4.1, 3.3.2, 4.2, 4.4, 5.4.1, 6.1, 8.1 i 8.2 PO IG. Warszawa, December 2014. http://www.ewaluacja.gov.pl/Wyniki/Documents/2_113.pdf
Statistical data concerning R&D project funding distributed in 2014 by NCN	NCN (2015) Statystyki konkursów 2014. Narodowe Centrum Nauki, Kraków. https://ncn.gov.pl/sites/default/files/pliki/NCN_statystyki_2014_pl.pdf
Evaluation of six instruments of R&I policy implemented by MNiSW	NA
Ex-ante evaluations of R&I support programmes	
Ex-ante evaluation of POIR	PSDB (2014) Ewaluacja ex ante Programu Operacyjnego Inteligentny Rozwój 2014-2020. Warszawa, January 2014. http://www.ewaluacja.gov.pl/Wyniki/Documents/2_105.pdf
Ex-ante evaluation of financial instruments proposed in POIR	WYG PSDB (2014b) Ocena ex ante instrumentów finansowych w ramach Programu Operacyjnego Inteligentny Rozwój. Warszawa. http://www.ewaluacja.gov.pl/Wyniki/Documents/2_106.pdf
Ex-ante evaluation of a new, strategic R&D programme of NCBiR „TECHMATSTRATEG”	NCBiR (2015a) Ewaluacja ex-ante programu strategicznego pn.”Nowoczesne Technologie Materiałowe – TECHMATSTRATEG”. Warszawa. http://www.ncbir.pl/gfx/ncbir/pl/defaultopisy/1396/1/1/ewaluacja_ex-ante_programu_techmatstrateg_prezentacja.pdf
Evaluation of regional smart specializations, carried out by the World Bank	NA
Evaluation and monitoring of national smart specializations, carried out by World Bank	NA

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